POWER

Vol. 34 NEW YORK, NOVEMBER 14, 1911 No. 20

A thousand miles, or two or three, according to where you now happen to be, in the direction of the setting sun lies the great and wonderful golden State California and her no less great and wonderful sisters of beyond the Big Divide.

Horace Greeley, years ago, said, "Go West, young man, go West." Many who followed his advice can testify today as to the soundness of it. That many are still following it is shown by the extraordinary growth in population of the whole Pacific Slope. According to the latest census returns, the State of Washington grew from about 518,000 inhabitants to over 1,141,000 during the years between 1900 and 1910. Los Angeles went from about 102,000 to about 319,000 during the same period. Although these are vivid examples, they are by no means exceptional and they serve to show how rapidly the Pacific Coast is growing in importance.

With growth in population and the industries comes growth in the various branches of operating engineering. For the right type of man, opportunities are abundant.

Conditions in the far West differ considerably from those in the eastern and middle sections of the country.

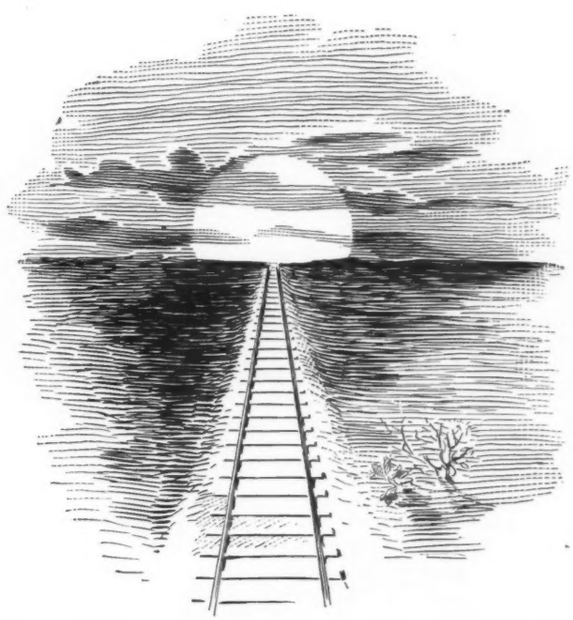
In the West water power is developed extensively. Every big city is served with water-generated current. "White coal" is the rather descriptive term applied to the water which turns the generator wheels.

The majority of the water-power stations are located in the country miles from the cities they serve and often in most picturesque settings. For the man who enjoys the invigorating air of the country along with the peace and quiet also to be found there, who enjoys puttering in his little garden patch, employment as an operator at one of these water-power stations is most congenial. The work is not arduous and the eight-hour shift is the rule. The pay is fair, considering the service required.

And for the ambitious man there is room ahead! He may advance to chief operator, foreman, superintendent of the division, etc.

In the steam-power plants crude oil is the chief form of fuel employed. Crude oil is much easier and more convenient to burn than coal; also, it can be burned more efficiently. The engineer who operates a crude-oil burning plant is spared many of the trials and annoyances of the man who must burn coal. In office-building plants oil makes a particularly desirable fuel. It is space-saving, convenient to handle and store, dustless, and it can be burned without smoke, soot or cinders.

The far West being a young and growing country, most of its power plants are new and well laid out. Such plants are a pleasure to operate.



As a general thing, the engineer in the far West is given more responsibility and, as a consequence, receives greater respect than the man in a corresponding plant in the East. Due to the rapidly growing condition of the section, newly created opportunities are more numerous.

The West is certainly a good section for the man who has ability and energy. No one should make the mistake, however, of thinking that he can go out there and fall into a soft snap without "delivering the goods."

An Office Building Central Station

By A. R. Maujer

An office-building plant which is laid out to furnish outside buildings with current, exhaust and live steam and water pressure for elevator service, through tunnels under street and alley.

The fuel used is oil; it is burned in a furnace which preheats the air supply.

The elevator pumping apparatus is a compound Corliss high-duty pumping engine of 2,800,000 gallons capacity per 24 hours.

Several of the hotel and office buildings in the business district of Los Angeles are equipped with miniature central stations which furnish, in most instances, light, heat, power and hydraulic-elevator service to outside buildings in the immediate vicinity. They are not strictly "block" central stations because in some cases buildings across the street, and even as far off as a block and a half, are furnished with the aforementioned services.

The Walter P. Story building, on the southeast corner of Sixth street and Broadway, one of the handsomest and most modern office structures in Los Anleges, contains a plant which at present serves a hotel, one other large office building, and a small store and office building. The capacity of the plant is sufficient, however, to serve ten or a dozen other buildings and it is expected that ultimately it will. The Story building is 11 stories high and contains some 300 offices. There are four plunger hydraulic passenger elevators and two freight elevators of the same type. The Hayward hotel, which is supplied with high-pressure steam for cooking and exhaust steam for heating and hot-water service, is nine stories high and has accommodations for about 350 guests. The distance between the Story building and the hotel is about 70 feet. The Los Angeles Trust and Savings Bank Building, which is supplied with exhaust steam for heating and hot-water service, is 11 stories high and contains 255 rooms; the distance between the Story building and the bank building is about 105 feet.

The William Garland building, which is supplied with light, heat and power, is three stories high and contains two stores and 60 rooms. The distance between this building and the Story building is 100 feet.

These three buildings are connected to the Story building by concrete-lined tunnels in which the service pipes and conduits are run.

A plan of the subbasement floor of the Story building, showing the arrangement of the power-plant apparatus, is given in Fig. 1. At present the plant contains three 150-horsepower horizontal return-tubular boilers, 66 inches in diameter and 18 feet long. The shells are made of ½-inch plate and have triple-riveted butt seams. The heads are of 9/16-inch plate. The steam drums are 36 by

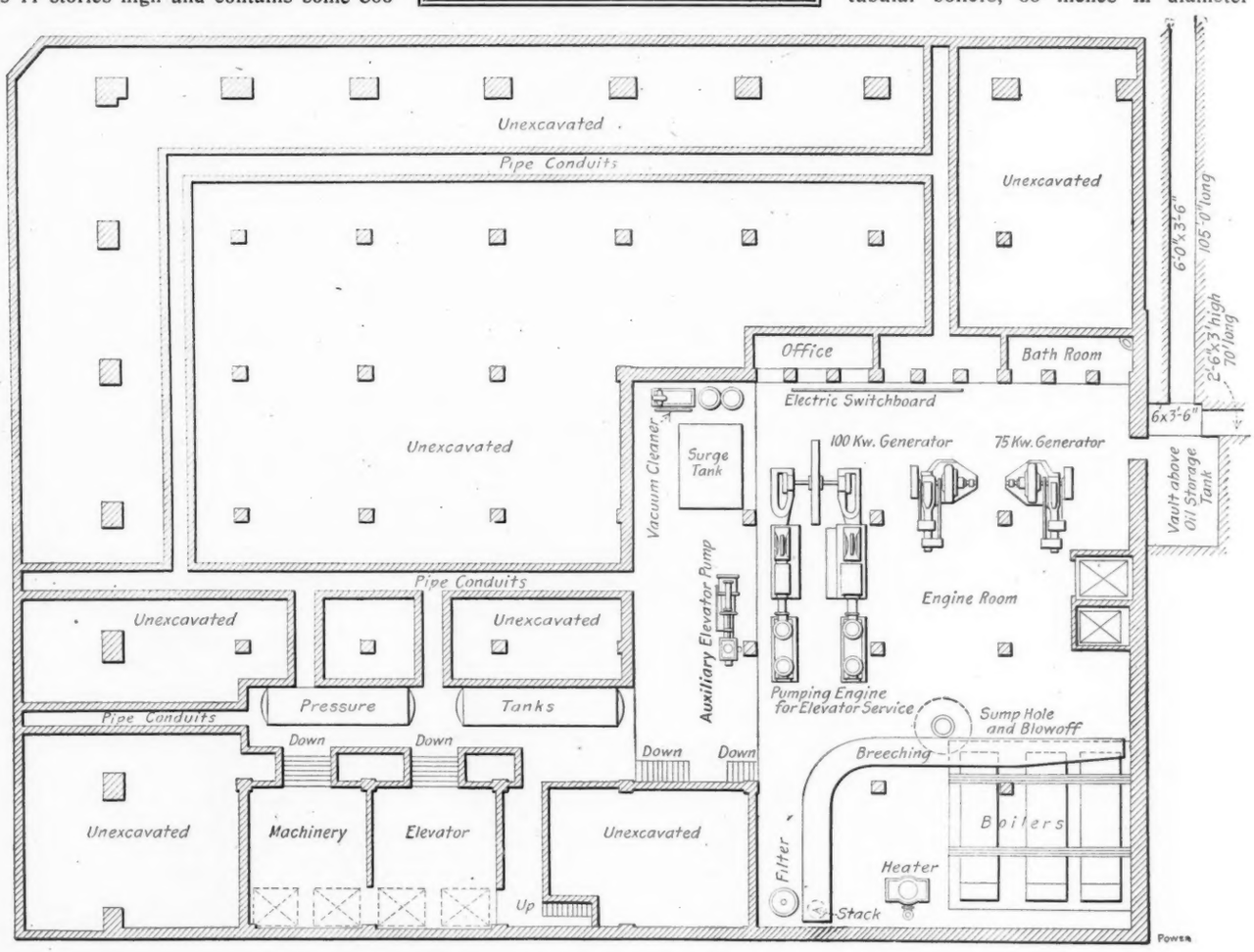


FIG. 1. PLAN AND ARRANGEMENT OF THE STORY BUILDING POWER PLANT

72 inches in size and built of 3/8-inch plate. Each boiler contains 98 tubes 3 inches in diameter and has 1555 square feet of heating surface. The steam pressure carried is 150 pounds per square inch.

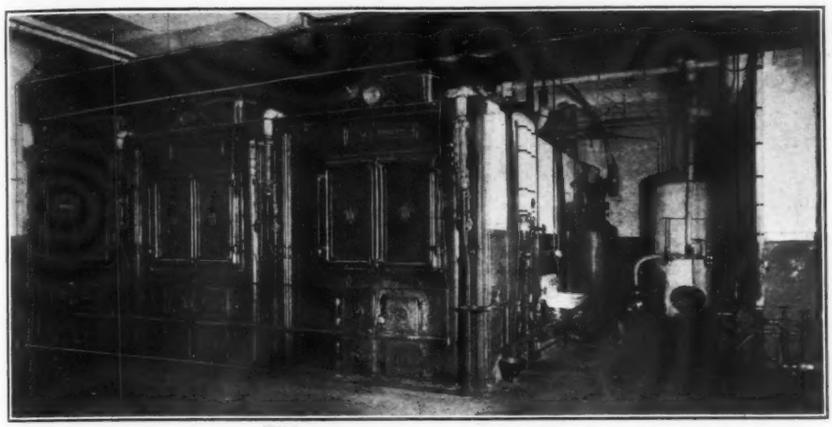


FIG. 2. BOILERS AND AUXILIARIES

The boilers are fitted with furnaces of special design, as shown in Fig. 3, for preheating the air supply to the burners. Firebrick slabs are laid on the entire grate surface, with the exception of the last quarter, in a bed of fireclay mortar and with joints of the same material. Another course of slabs is carried on loosely laid fireblocks which are about 3 inches high and arranged as indicated in Fig. 3. At the front of the furnace and above the upper course of slabs a firebrick wall and arch extend across the furnace. In the center of this wall an arched passageway extends forward to within a short distance of the boiler front. The burner extends into this passageway to a point just back of the rear face of the dividing wall. All openings around the firedoor and burner are stopped up so that no cold air can get into the combustion chamber. The air supply is admitted through the ashpit doors and passes to the rear under the grates, up through the grates and then forward between the two courses of firebrick slabs, circulating around the supporting blocks and being heated as it goes by the almost incandescent roof slabs; at the front it enters the arched passageway and mixes from all sides with the jet of oil.

The construction of the burner, which is of the internal mixing type, is shown in Fig. 4. Steam enters at the top and is discharged through a double set of jet holes in the nozzle into the mixing barrel, where it comes in contact with the oil which is supplied from below. The size and width of the jet, which is fishtail in shape, are determined by the opening at the end of the burner and vary in each case with the capacity of the boiler, width of setting, etc.

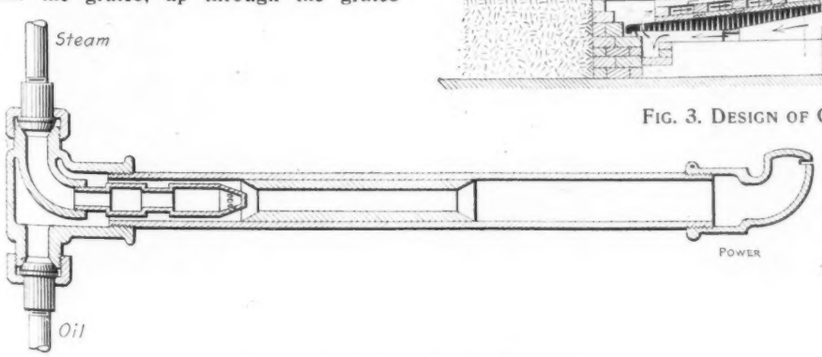


FIG. 4. DESIGN OF OIL BURNER

That this furnace and burner are capable of yielding satisfactory results is shown by a recently conducted test. The oil fired during this test had a heat value of approximately 18,000 B.t.u. per pound of oil as fired. The results showed an average evaporation from and at 212 degrees of 14.41 pounds of water per pound of oil. This is equivalent to an efficiency of about 77.7 per cent.

FUEL-OIL SYSTEM

The manner of storing the fuel oil and supplying it to the burners departs a little from average practice. The storage tanks, two in number, are 2 feet below the engine- and boiler-room floor, or 32 feet below grade, and just outside the building line and directly beneath the alley which runs back of the building. Each tank is 6 feet 6 inches in diameter, 22 feet long and has a capacity of about 550 gallons. The arrangement of the tanks and piping is shown diagrammatically in Fig. 5. An air pressure of about 40 pounds per square inch is on a tank when it is feeding to the boilers.

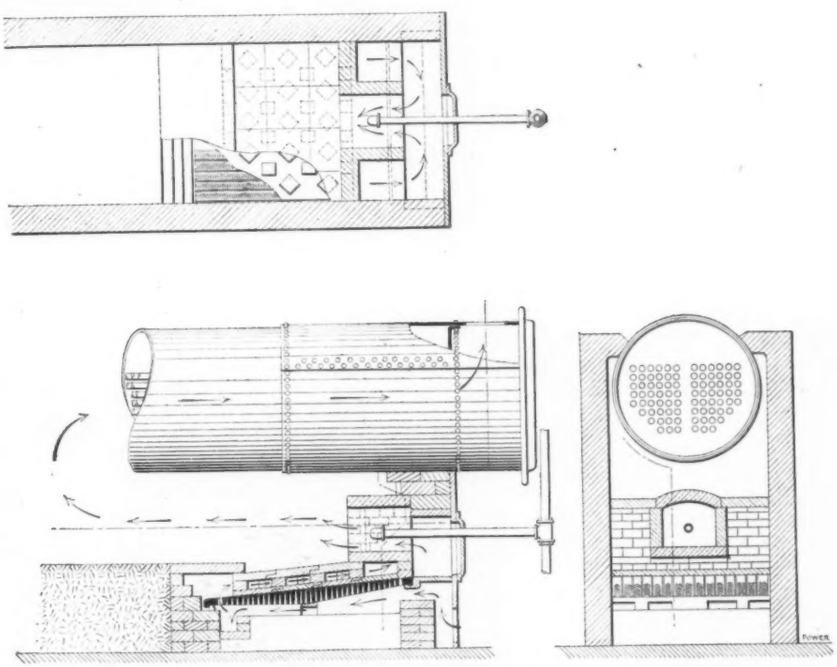


FIG. 3. DESIGN OF OIL-BURNING FURNACES

The filling pipe extends up to the surface of the alley, where it terminates in a suitable plug. The oil is brought to the building in tank wagons and filled by gravity into either tank as desired. The small pipes *A* serve to rid the tanks of any water which may settle out of the oil or be carried into the tanks by the compressed air. The open discharge of these pipes to a funnel in the floor makes it possible to tell exactly when all of the water has been drained out.

The oil receives no preliminary heating but goes to the burners at normal temperature. In the burners it mixes with the steam and an increase in its temperature takes place before the oil and steam leave the nozzles.

Boiler Auxiliaries

The boilers are fed by two Davidson simplex pumps, 7 and 4 by 10 inches in size. The feed water is pumped to the boilers through a Keystone pressure filter from the hotwell in the bottom of a closed heater, described by its designer and builder, J. F. Connell, of Los Angeles, as an automatic receiver, steam drum and water heater. This heater is shown in the background of Fig. 2 and its design and construction are illustrated in another portion of the paper.

The hot water for the house service is supplied by this same heater. All of the exhaust from the various engines and pumps in the plant is led to the heater and that which is not required for heating the water passes on through to the radiators distributed throughout the several buildings served.

Generating Units

The present electrical generating equipment is shown in Fig. 6. It consists of two Westinghouse three-wire direct-current 125-250-volt generators; one has a rated capacity of 80 kilowatts and the other 110 kilowatts.

The generators are direct driven by horizontal tandem-compound center-crank self-oiling engines built by the Buffalo Forge Company.

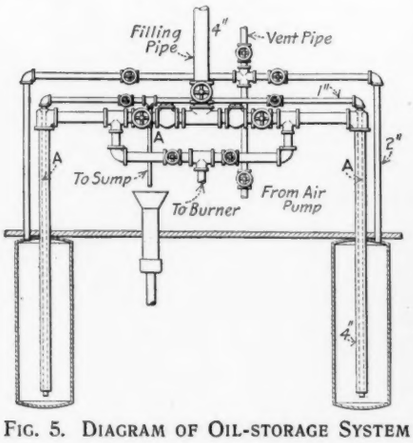


Fig. 5. Diagram of Oil-storage System

During the summer months, because of the light load, the low-pressure piston and eccentric of the small unit are taken off and the steam is bypassed from the high-pressure cylinder direct to the exhaust. In this way, with the engine running simple, the steam economy is better under the light load than if both cylinders were employed.

Elevator Pumps

There are two elevator pumps. The main one is a 2,800,000-gallon cross-compound Monarch-Corliss pumping engine, built by the H. N. Strait Company and shown in Fig. 7, which gives a view from the low-pressure side. The steam cylinders are 17 and 27 inches in diameter with a 36-inch stroke; the water piston is 9 inches in diameter. This engine has the capacity to furnish water for the elevators not only in the Story building but in a half-dozen others as well and it is expected that ultimately that number of buildings will be served.

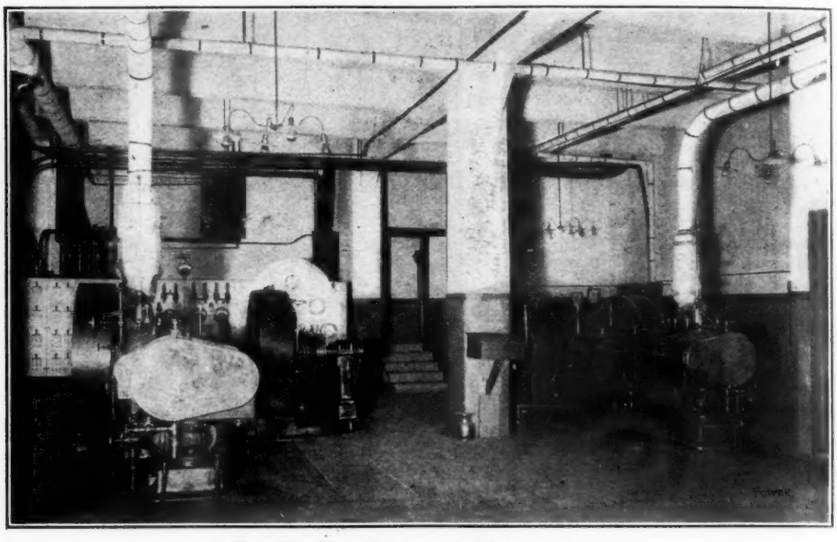


Fig. 6. The Electric Generators

To prevent the engine from stalling on dead center during a temporary period of no load, it has been fitted with an automatic bypass valve, controlled in the manner illustrated diagrammatically in Fig. 8, which also illustrates the hydrostatic governor for limiting the speed of the engine in accordance with the work required.

The water pressure from the elevator tanks acts against the under side of the diaphragm *C* and the pressure of the spring *D* is brought to bear on the upper side in the manner shown. As the pressure in the tanks rises, the pin attached to the diaphragm forces up the lever *E* which, acting through the mechanism shown, shifts the knockoff-block rods and shortens the high-pressure cutoff. When the pressure in the tanks falls, the knockoff blocks are shifted in the opposite direction and the cutoff is lengthened.

If the governor belt should break, the weighted rider pulley *F* would cause the cock *G* to open and admit air pressure to the under side of the piston *H*, which would rise and force the governor to its highest position and thus cut off the steam supply.

To prevent the engine from coming to a full stop and consequently stalling on dead center every little while, the auxiliary governor *H* is belted to the main governor as shown. As the speed of the engine decreases and the weights of this governor fall, they operate through suitable levers and links to open the four-way valve *I* so as to admit the air pressure supplied through the pipe *J* to the under side of the piston in the

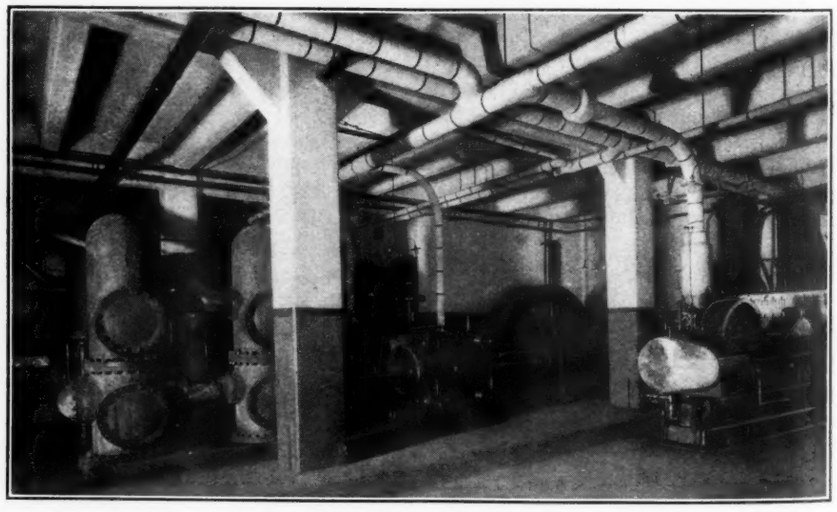


Fig. 7. The Main Elevator Pump

bypass valve *K*. The pressure forces the piston up and thereby opens the valve. This bypass valve is piped so as to connect the fore-and-aft suction chambers of the pump. With the valve open, some water surges from one suction chamber to the other—just enough to keep the engine turning slowly when no water is being discharged.

As soon as water is required in the elevator tanks the engine speeds up a bit and the weights of governor *H* rise. This throws the four-way valve *I* into the opposite position and thereby admits air pressure to the top of the piston in the bypass valve *K* and at the same time allows the air beneath the piston to escape through the exhaust pipe of the four-way valve. The bypass valve then closes and cuts off the flow of water between the suction chambers.

The auxiliary elevator pump, which is used at night and on Sundays and holidays, is a Davidson compound simplex, controlled by a Ford governor. It is 14, 24 and 12 by 20 inches in size. This pump is shown in Fig. 9.

A general idea of the construction of the service tunnels may be had from Fig. 11. This shows the entrance, in the Los Angeles Trust and Savings Bank building, of the tunnel which connects that building with the Story building plant. The tunnel is 3 feet 6 inches wide by 6 feet high to the top of the arch.

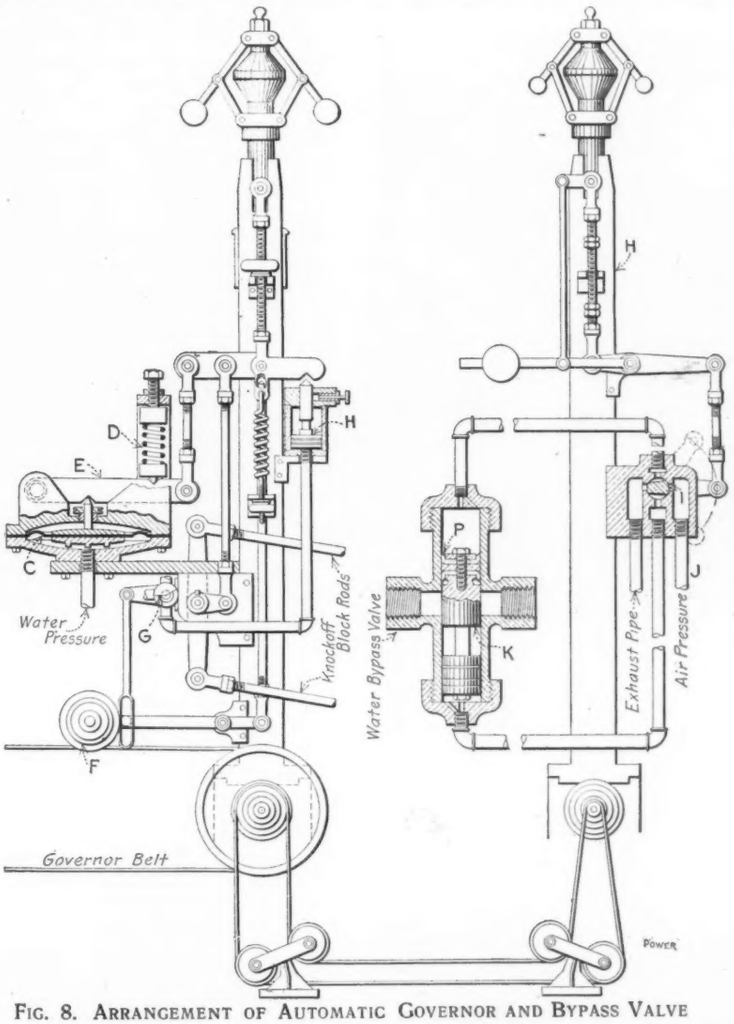
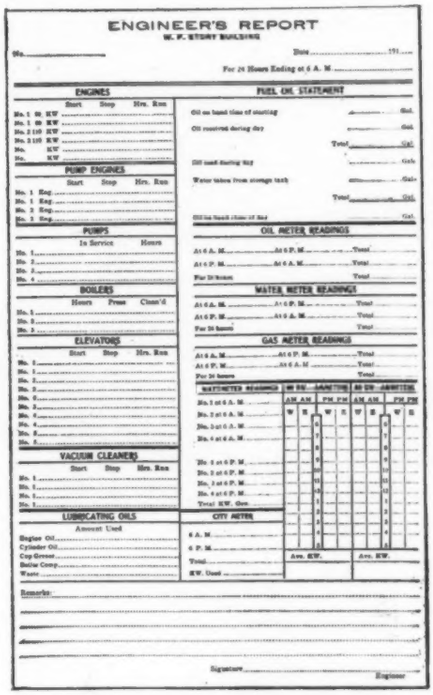


FIG. 8. ARRANGEMENT OF AUTOMATIC GOVERNOR AND BYPASS VALVE

Each day the assistant engineer fills out a duplicate report form such as is shown in Fig. 10. This is inspected and signed by the chief engineer, who retains one copy for reference and sends the other copy to the office of the building.


ENGINEER'S REPORT

W. P. STORY BUILDING

No. _____ Date _____ 191__

For 24 Hours Ending at 6 A. M. _____

ENGINES — Start, Stop, Hrs. Run
No. 1 St. MW
No. 1 Ob MW
No. 2 Ob MW
No. 2 Ob MW
No. MW
No. MW

PUMP ENGINES — Start, Stop, Hrs. Run
No. 1 Reg.
No. 1 Reg.
No. 2 Reg.
No. 2 Reg.

PUMPS — In Service, Hours
No. 1
No. 2
No. 3
No. 4

BOILERS — Hours, Press, Clean'd
No. 1
No. 2
No. 3

ELEVATORS — Start, Stop, Hrs. Run
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 7
No. 8

VACUUM CLEANERS — Start, Stop, Hrs. Run
No. 1
No. 2
No. 3
No. 4
No. 5

LUBRICATING OILS — Amount Used
Engine Oil
Cylinder Oil
Cup Grease
Boiler Comp.
Waste

FUEL OIL STATEMENT
Oil on hand time of starting _____ Gal.
Oil received during day _____ Gal.
Total _____ Gal.
Oil used during day _____ Gals.
Water taken from storage tank _____ Gals.
Total _____ Gal.
Oil on hand time of this _____ Gal.

OIL METER READINGS
At 6 A. M. _____ At 6 P. M. _____ Total
At 6 P. M. _____ At 6 A. M. _____ Total
For 24 hours Total

WATER METER READINGS
At 6 A. M. _____ At 6 P. M. _____ Total
At 6 P. M. _____ At 6 A. M. _____ Total
For 24 hours Total

GAS METER READINGS
At 6 A. M. _____ At 6 P. M. _____ Total
At 6 P. M. _____ At 6 A. M. _____ Total
For 24 hours Total

WATTMETER READINGS — 60 CY. — SANCTON — 25 CY. — ARMSTRONG
No. 1 at 6 A. M. — AM AM — PM PM — AM AM — PM PM
No. 2 at 6 A. M. — W S — W S — W S — W S
No. 3 at 6 A. M.
No. 4 at 6 A. M.
No. 1 at 6 P. M.
No. 2 at 6 P. M.
No. 3 at 6 P. M.
No. 4 at 6 P. M.
Total KW. Gen.

CITY METER
6 A. M.
6 P. M.
Total
KW. Used
Ave. KW.
Ave. KW.

Remarks:

Signature _____ Engineer

FIG. 10. ENGINEER'S REPORT FORM

The oil burner and the furnace used in this plant, and the fuel-oil storage and supply system, as well as the hydrostatic governor and automatic bypass valve on the pumping engine, were designed and patented by John P. Proper, the chief engineer of the building.

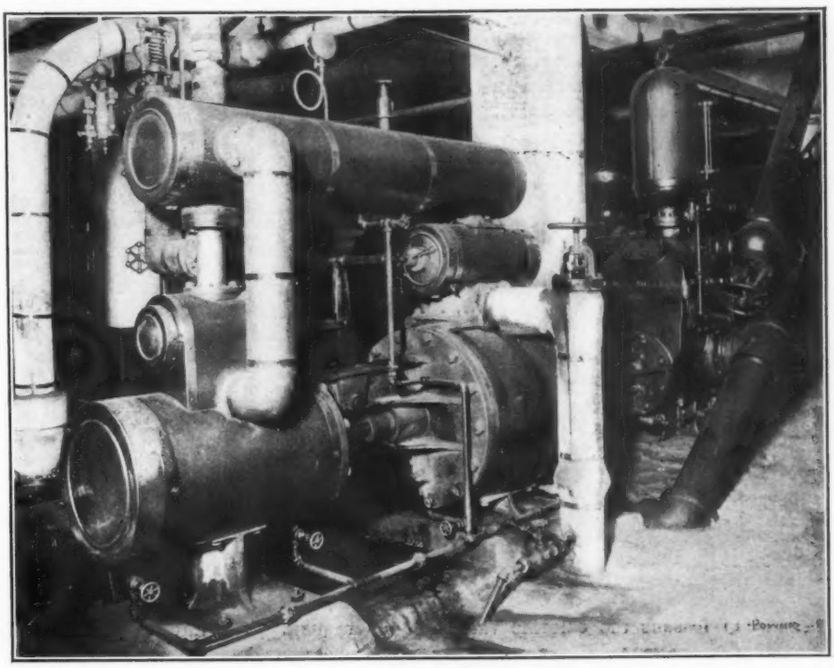


FIG. 9. THE AUXILIARY ELEVATOR PUMP

Notes on Crude Oil Fuel

By F. S. Wade

In California, where crude petroleum in one form or another is used exclusively as a steam-making fuel, the question of the relative fuel value of different grades is often raised. Much confusion exists on this subject on account of the practice of stating the calorific value of oils in terms of heat units per pound, while the oil is bought and paid for by the barrel of 42 gallons. The accompanying table, made up of analyses published by the California State Mining Bureau, together with some analyses made by the writer, is instructive as showing the relation between the calorific value per pound and the calorific value per pint of typical California crude oils. All analyses are stated for oil entirely free from moisture.

From the figures in the table it is apparent that the heat units per pound of oil increase, and the heat units per pint of oil decrease, as the degrees Baumé grow higher. Also an excessive quantity of sulphur (see samples 6 and 11) lessens the calorific value of an oil to a considerable extent.

It is evident that the cheapest oil for steam making is that having the lowest degrees Baumé, provided it is bought by the gallon. It must be borne in mind, however, that the very heavy oils, say 11 or 12 degrees Baumé, are extremely viscous and very difficult to handle unless heated to at least 150 degrees Fahrenheit. All things considered, an oil of about 14 degrees Baumé, not containing an excess of sulphur, is the most economical for fuel purposes.

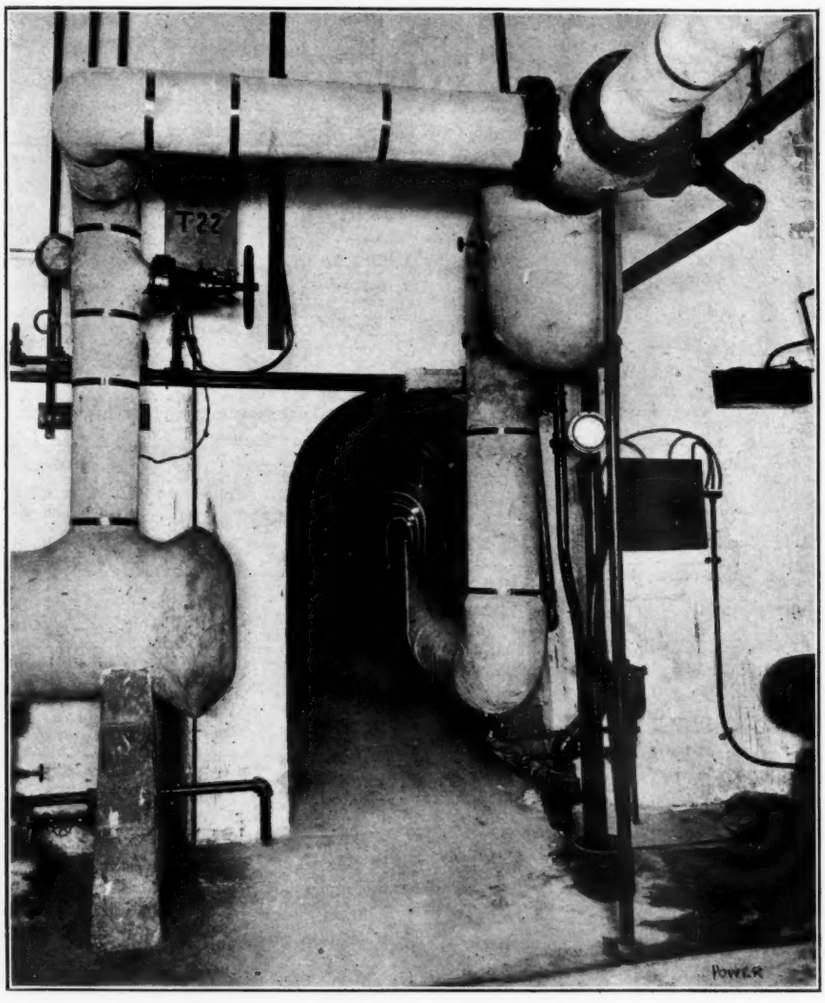


Fig. 11. Showing Construction of Tunnels

Great variations in the calorific value of oils of apparently the same gravity are often found and are due to water in the oil, which in many cases is undetected and not corrected for on account of the rather general use of the so-called "gasolene test" for water. This test is made by mixing equal portions of gasolene and oil and allowing the mixture to stand 24 hours. At the end of this time the percentage of water can, supposedly, be read off on a scale at the bottom of the test cylinder. As a matter of fact this test rarely with any oil, and almost never with the heavier oils, reveals the full and correct amount of water present. The widespread specification of this test in oil contracts is, therefore, greatly to be regretted. In the experience of the writer, water in crude oil can be determined satisfactorily only by the use of a high-speed centrifugal testing machine or by distillation.

It is very often necessary to correct the gravity or volume of fuel oil for temperature. A standard temperature of 60 degrees Fahrenheit is almost universally assumed and a deduction in gravity of 0.1 degree Baumé is generally made for each degree Fahrenheit in excess of 60 degrees. Where the oil temperature is below 60 degrees Fahrenheit, a corresponding addition to the observed degrees Baumé is made. This correction figure, giving an expansion factor of 0.0006 for each degree Fahrenheit, was undoubtedly derived from the lighter paraffin oils of Pennsylvania, but is in no way correct for the asphaltic oils of California.

Repeated experiment has proved that the expansion factors of California oils between 12 and 22 degrees Baumé is substantially 0.0004 per degree Fahrenheit, which gives a correction in gravity of 0.06 degrees Baumé for each degree Fahrenheit of the oil above or below 60 degrees.

PROPERTIES OF CALIFORNIA CRUDE OILS

No.	District	Specific Gravity		Pounds per Gallon	Sulphur, Per Cent.	B.t.u. per Pound	B.t.u. per Pint
			Degrees Baumé				
1	Newhall	0.9880	11.7	8.24	0.69	18,481	19,030
2	Sunset	0.9818	12.6	8.19	0.90	18,655	19,093
3	Coalinga	0.9756	13.5	8.14	0.78	18,612	18,933
4	Los Angeles	0.9709	14.2	8.10	1.18	18,623	18,906
5	Newhall	0.9669	14.8	8.07	0.62	18,700	18,847
6	Lompoc	0.9576	16.2	7.99	4.43	18,464	18,433
7	Los Angeles	0.9556	16.5	7.97	0.85	18,787	18,724
8	Newhall	0.9472	17.8	7.90	0.49	18,830	18,602
9	McKittrick	0.9428	18.5	7.87	0.77	18,724	18,400
10	Fullerton	0.9396	19.0	7.84	1.09	18,794	18,418
11	Santa Maria	0.9333	20.0	7.79	2.08	18,664	18,168
12	Santa Paula	0.9327	20.1	7.78	0.32	19,087	18,560
13	Puente	0.9272	21.0	7.74	0.62	18,894	18,275
14	Fullerton	0.9150	23.0	7.64	0.94	19,046	18,176
15	Fullerton	0.9091	24.0	7.59	0.51	19,016	18,030
16	L. A. Fuel Distillate	0.9061	24.5	7.56	0.82	19,018	17,973
17	Puente	0.8946	26.5	7.47	0.38	19,224	17,937
18	Santa Paula	0.8811	28.9	7.35	0.48	19,165	17,612
19	Santa Paula	0.8766	29.7	7.32	0.72	19,161	17,515
20	Coalinga	0.8679	31.3	7.24	0.38	19,330	17,494
21	Fullerton	0.8537	34.0	7.12	0.41	19,399	17,267

Pioneer Power Plant of California

By L. R. W. Allison

This plant of 600 and finally 1200 kilowatts capacity has been in active 24-hour service since 1896. It was California's first hydroelectric plant and is now being dismantled.

The recent announcement that the Nevada power house, the pioneer generating plant of California, is to be dismantled by its present owners, the Pacific Gas and Electric Company, lends particular interest to this small but notable power station. Its name is prominently connected with hydroelectric generation and long-distance transmission development, and its period of inception marks one of experimental work which has contributed its quota of beneficial results for advancement of like enterprises.

Location and History

Located on the South fork of the Yuba river, at the base of a V-shaped cañon, about half a mile below the ridge of a chain of the Sierra mountains in Nevada county, the Nevada power house—familiarly known as the "Rome" power plant, through the association of Romulus R. Colgate with its founding—has been in active 24-hour service from the year 1896 up to a recent period.

The proposed harnessing of the waters of the Yuba river extends back to 1891, when Eugene J. de Sabla, Jr., largely identified with mining and numerous power enterprises in the State, organized the Nevada County Electric Power Company. The initial attempt to construct a dam across the river for a ditch and flume system met with failure through a flood in 1892. The succeeding venture, in the summer of 1895, proved successful, work being carried to completion the latter part of the year. The dam, constructed of logs bolted to the river bedrock, was 28 feet high, with a length from bank to bank of the stream of 107 feet. The wood flume, 6 feet wide, 4½ feet deep and about 3.3 miles long, was built at a gradient of 26 feet to the mile, and delivered a constant flow of approximately 5800 miner's inches into a 48-inch steel pipe. This intake diminishing, through a distance of 300 feet and a perpendicular descent to the plant of 190 feet, to 42 inches in diameter to increase the energy of the jet, discharged into a steel receiver for delivery to the waterwheels.

The difficulty experienced in getting the machinery to the plant may be readily imagined. From Colfax to Nevada City the diminutive Nevada county narrow-gage railway was used, and from this point it was hauled by team to the ridge overlooking the site, a distance of about 5 miles, and entirely up grade, a special road being constructed. Each generator weighed nearly six tons, and twelve-horse teams were often required to gain this summit of 1700 feet elevation. The machinery was lowered about 1300 feet to the bottom of the gorge by means of log rollers, hawsers and cables. The entire contract for dam, flume and power plant was carried out by John Martin, prominently associated with electric-power development in California.

Construction and Equipment

The power plant, Fig. 1, is built on a small, cleared-off ledge on the border of the stream. The foundations are of solid granite. The plant is connected to a boarding house, on the opposite side of the river, by a suspension bridge; the hanging stairway, at the extreme right of the illustration, leads from the cañon to the Nevada City road. The installation consisted of two 300-kilowatt Stanley generators of 133-cycle, two-phase, inductor type, operating at 400 revolutions per minute and generating at 5500 volts. The two generators were each direct-connected to three and four Pelton wheels respectively, each waterwheel being 3 feet in diameter and having two nozzles. The maximum output of the plant at full overload capacity was 800 kilowatts.

The switchboard, operating with open-air, automatic circuit-breakers, was placed at the end of the power house. The two-phase circuit was carried to Grass valley, about 8 miles distant, on poles 30 feet high, cut from the right-of-way for use. With connection about midway of this distance, a branch line was constructed to Nevada City. At these two places substations were erected to step down the voltage from 5500 to 2200 for mine operation, and to 550 and 110 volts for industrial and domestic purposes.

The great demands made upon the little plant soon necessitated an enlargement of capacity, and in 1898 a reservoir was formed at Lake Vera, about 3 miles southeast of the station. This new impounding system comprised about 42 acres of land, with an average depth of 52 feet. It was indirectly fed from the large watershed of the Sierra mountains north, and capable of a constant flow of 1000 miner's inches for a 30-day period. The water was conveyed to the plant by ditch, flume and steel pipe, as in the former instance. A break in the Lake Vera dam in 1905 reduced its hight to 40 feet, and proportionally reduced the capacity to a 10-day flow. The supply from the Yuba river was accordingly diminished to a normal flow of 3800 miner's inches. To provide for this augmentation in water power, an addition was erected to the plant. Fig. 1 shows the original building at the left, the connection between this and the larger portion, constructed later, being easily distinguished. The pipe lines shown from left to right, convey the Yuba river and the Lake Vera flows, known as the low-head and high-head respectively, both

Fig. 1. Exterior View of California's Pioneer Plant

being firmly anchored at the base of the incline.

The later installation comprised two additional Stanley generators, of the same size and type as noted, driven with Tutthill waterwheels mounted on the same shaft as the low-head Pelton wheels. All machines were operated in parallel, the remodeled switchboard, Fig. 2, in the new addition of the plant being equipped with Martin open-air switches. With this total capacity, an average of 1200 kilowatts, the plant has been in continuous service up to a few months ago, being closed down through the abolishment of the 133-cycle type of generator by its owners.

Historical Interest

Great historical interest is attached to the plant. Following the organization of the Nevada County Electric Power Company, the Bay Counties Power Company was formed in 1900 by the combination of this company and the Yuba Power Company. In 1903, the California Gas and Electric Corporation was organized to take over this and other systems, while in 1906 the entire properties came under the control of the Pacific Gas and Electric Company, tying the little Nevada power house in with a general system covering an area of over 32,400 miles of California territory, and serving two thirds of the population of the State.

During its period of operation the station has netted total earnings exceeding $1,000,000. While larger and modern generating plants now hold the center of attraction, the "Rome" power house is destined to hold first place in the history of hydroelectric-power development in this country.

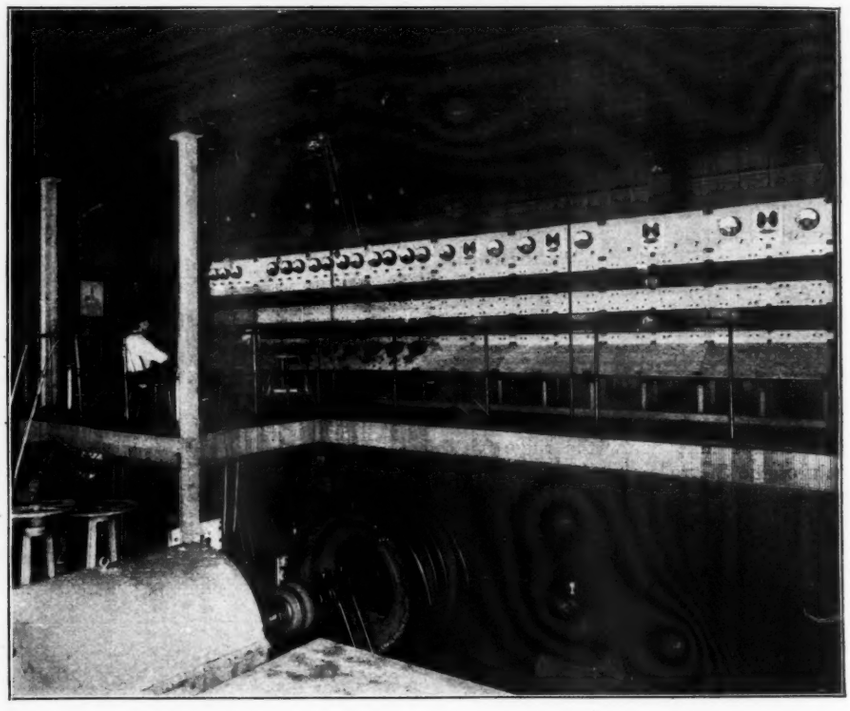


Fig. 2. Remodeled Switchboard in New Addition of Plant

A Commercial Water Power Problem

By Prof. W. D. Ennis

The flow, available horsepower, power value and lease value are computed for a small water-power development used in conjunction with a steam plant.

There is a small water-power development in this country, dating back over a hundred years, in which various manufacturing plants hold a more or less absolute ownership. In connection with one of these plants, the following questions came before the writer for investigation:

1. The amount of water (flow) owned;
2. Its value for producing power;
3. Its equivalent lease value;
4. Its value for other purposes than hydraulic power.

The mill had the right to use all water that would flow through an aperture 6 inches high and 6 feet wide in the side of the raceway (see Fig. 1), provided that it returned this water to the tailrace at a 30-foot lower level. The power company was obliged to maintain at all times a headrace water level 30 inches or more above the top of the aperture.

Flow

The simplest way of determining the flow through the aperture was by actual measurement of velocity; but a simple analysis serves to nicely check and confirm experimental values. This analysis depends upon the fundamental law of falling bodies as expressed by the formula:

$$v = \sqrt{2gh}$$

where,

v = Velocity in feet per second;
g = Acceleration due to gravity, or 32.2;
h = Head in feet.

This may be applied to the water falling from the headrace level to the aperture; but the difficulty is encountered that h has one value, namely, 2½ feet, at the top of the aperture, and another value, 3 feet, at its bottom. Nor is the mean velocity that corresponding to a mean head of 2.75 feet; for the velocity varies, not directly as the head, but as its square root. Therefore, the mean velocity for computation of flow quantity will be that corresponding to a head greater than 2.75 feet and less than 3 feet. To find this mean velocity the following computations are made:

Point of Aperture	Head, Feet	Velocity in Feet per Second
Top	2.5	12.7
1 inch below top	2.5833	12.9
2 inches below top	2.6667	13.15
3 inches below top	2.75	13.35
4 inches below top	2.8333	13.5
5 inches below top	2.9167	13.75
Bottom	3	13.9

These values may be plotted as in Fig. 2, the area $a\,b\,c\,d$ divided by the distance $d\,c$, or if the ordinates between a and b be averaged the true mean head will be found, from which the mean velocity may be read directly. This mean head appears to be 2.78 feet, and the corresponding velocity 13.37 feet, or,

$$v = \sqrt{64.4 \times 2.78} = 13.37 \text{ feet per second}$$

The quantity of water delivered through the aperture will be equal to the mean velocity multiplied by the area, or

$$13.37 \times 0.5 \times 6 = 40.11 \text{ cubic feet per second}$$

The actual velocity is always less than a computation of this sort indicates, and the aperture stream may be regarded as somewhat contracted from the full dimensions of the opening. Assuming the

cofficient of discharge under these conditions to be 0.6, the probable flow is

$40.11 \times 0.6 = 24.07$ *cubic feet per second*

At 60 degrees Fahrenheit, 1 cubic foot of water weighs 62.37 pounds; hence, the weight of water flowing is

$24.07 \times 62.37 = 1504$ *pounds per second*

The maximum head of this water is 30 feet, but at least 4 feet of this head will be lost in the arrangement of the waterwheels; hence the theoretical available energy is

$1504\ (30 - 4) = 39{,}120$ *foot-pounds per second*

or

$39{,}120 \div 550 = 71$ *horsepower*

With 85 per cent. turbine efficiency,

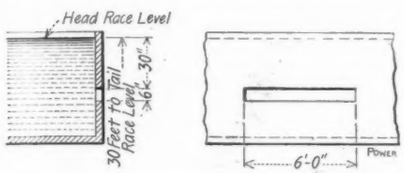


FIG. 1. OPENING IN TANK

$71 \times 0.85 = 60.3$ *horsepower*

would be obtained.

POWER VALUE

The plant was already equipped with a steam plant and with the waterwheel. It burned about 5 pounds of coal per horsepower-hour, which, at $2.75 per ton, gave a fuel expense of

$$\frac{275 \times 5}{2000} = 0.6875 \text{ cent per horsepower-hour}$$

With a conservative allowance for labor and supplies, the operating cost for steam power was close to 1 cent per horsepower-hour. The plant operated steadily, and 60.3 horsepower could be used about 6000 hours per year. To provide this from the steam plant would have involved a cost of about

$6000 \times 60.3 \times \$0.01 = \$3618$ *per year*

on the basis adopted. If the plant had had insufficient steam power, or if it were a question of installing waterwheels, the fixed charges would have required consideration. Thus, suppose additional steam equipment to have been necessary, involving a first cost of $40 per horsepower, on which the fixed charges (interest, depreciation, taxes, insurance, etc.,) were 15 per cent.; the cost of 60.3 horsepower in steam would have been increased by

$\$40 \times 60.3 \times 0.15 = \$361.80$ *per year*

making the water power worth (if ignoring the slight attendance necessary and the sale value of the old waterwheel)

$\$3618 + 361.80 = 3979.80$ *per year*

On this basis the value of ownership in the water was that sum of money which, invested, would yield an annual income of $3979.80. Taking the equivalent rate of interest on such an investment at 6 per cent., the sale value of the water rights would be

$\$3979.80 \div 0.06 = \$66{,}330.$

LEASE VALUE

The plant could, of course, afford to pay $3979.80 per year for the water if it had not the necessary steam plant, or $3618 per year if it had. These figures are equivalent respectively to $1326.60 and $1206 per square foot of aperture per year. Actual leases were being made at much lower figures, because the water power had to compete with more economical steam plants, using 3 instead of 5 pounds of coal per horsepower-hour, and perhaps running only 10 hours per day. The question then arises, at what price is the plant likely to be offered for a deed of its water rights? Clearly not $66,330, for a good steam plant could not show even a 4 per cent. return on such an investment to replace steam power. Assuming the leases to be made at $500 per square foot per year, on a 6 per cent. basis the value of the right is then not over

$\$500 \times 3 \div 0.06 = \$25{,}000.$

IMPROVEMENT OF PLANT

As a matter of fact, money might be borrowed for improving the present steam plant to such extent as to produce power at a total expense, including fixed charges, of 1 cent per horsepower-hour, or $60 per year. This, however, would involve an annual expenditure of $3618

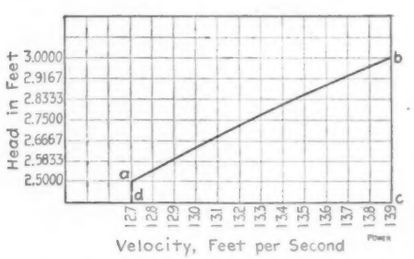


FIG. 2. CHART FOR FINDING MEAN VELOCITY

for 60.3 horsepower, which the waterwheel now avoids. It is difficult to escape the conclusion that the poor economy of the present steam plant makes the water right about $66,000; that this is more than twice what it is worth commercially, and that the owners cannot realize on the assets by putting in a better steam plant and selling the water rights.

WATER FOR CONDENSING

It was suggested that the water might be more valuable if used for condensing the exhaust steam from the engines than for power. Consider all of the water to be thus available and that 30 pounds of water will condense 1 pound of steam, the condensed steam and water being, of course, returned to the tailrace. If 30 pounds of steam be used per horsepower-hour, when running noncondensing, and 23½ pounds when running condensing, the saving in fuel due to condensing would be

$$\frac{30 - 23\frac{1}{2} \times 100}{30} = 21.6 \text{ per cent.}$$

The value of the fuel saved per horsepower-hour would then be

$0.6875 \times 0.216 = 0.1483$ *cent*

The condensing-water consumption per horsepower-hour would be

$23\frac{1}{2} \times 30 = 705$ *pounds*

The value of this water is then

$0.1483 \div 705 = 0.0002102$ *cent per pound*

FIG. 3. CASTING ATTACHED TO ORIFICE IN PRESENT CASE

Since the available flow is 1504 pounds per second, the revenue from the water used for condensing would be, per year,

$$60 \times 60 \times 1504 \times 0.0002102 \times \frac{6000}{100} =$$

$68,600

It would suffice to condense the steam from an engine capacity of

$1504 \times 60 \times 60 \div 705 = 7660$ *horsepower*

However, the following additional factors should be considered:

1. The engine capacity, which was under 2000 horsepower;
2. The first cost of the condensing equipment;
3. Higher-priced attendance necessary.

All of these being taken into account, it appears that the best plan would be for the plant to use as much of the water as it can for condensing purposes, generating power with the remainder; for the economy of the steam plant to be improved by better operation; and for the idea of disposing of the title to water to be abandoned, at least until better steam-plant economy has been attained.

TITLE VERSUS RENTAL

The power company desiring to acquire ownership in all the water, and offering a permanent lease in lieu thereof, the plant might consent to deed its ownership to the power company in consideration of the granting of a perpetual prepaid lease; but since the former would then be surrendering property for a covenant, it would be safer to arrange for payment by the power company of the capitalized value of the lease rates—say at 6 per cent. and $500 per square

foot per year—the power company would pay to the mill

$$\$500 \times 3 \div 0.06 = \$25{,}000$$

in cash, and at the same time contract to perpeutally furnish the present stream of 3 square feet of cross-section at an annual rental of $1500. If suitable guarantees could be furnished, this might be as satisfactory to the mill as its present tenure, and it would provide it with some additional working capital. If the contracted lease is of 99 years' duration only, the payment should exceed $25,000.

Increase of Flow

The conduit attached to the aperture shown in Fig. 1 was not an open weir, but an iron casting of the shape indicated in Fig. 3. Many centuries back, it is said, when Roman peasants drew water for irrigation from the aqueducts, they employed this same device. Now proceeding to consider its effect, let a tank of water be provided with a converging orifice, as in Fig. 4, the area at

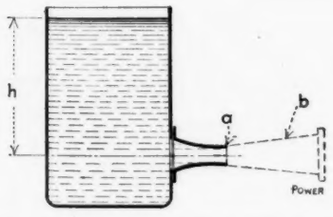


Fig. 4. Tank with Nozzle for Increasing Flow

the outlet a being one square foot. The flow of water, in cubic feet per second, is, theoretically,

$$Q_a = a v = a \sqrt{2gh}$$

If a diverging mouthpiece b be attached to a, the velocity at that point will be greatly increased, the head equivalent to the partial vacuum produced at the contracted section being added to the visible head. The velocity at the outlet of b will become $\sqrt{2gh}$. Let the area at this outlet be $3a$, from which the flow at b is

$$Q_b = 3 a v_b = 3 a \sqrt{2gh}$$

and as this must equal the flow at a,

$$3 a \sqrt{2gh} = a \sqrt{2gh_a}$$

from which h_a, the head at a, may be found; this will, of course, exceed h. If h equals 4 feet, then, theoretically, h_a would almost exceed the physically possible limit, becoming

$$4 \times 3^2 = 36 \text{ feet.}$$

Under these conditions, the flow of water might be tripled, if there were no excessive friction losses. In the present case, with a maximum head of only 3 feet, the theoretical increase of flow is even greater. The principle is that of the "vena contracta," and the presence of the iron casting of Fig. 3 invalidates all of the foregoing calculations. Whether the use of this device is legitimate, or whether by long toleration the right to employ it has been established, are other questions. It is interesting to note, however, that it has been in service for many years with the knowledge of all parties concerned.

Largest Corliss Engine on the Pacific Coast

A recent addition to the San Francisco, Oakland & San José Consolidated Railway, Oakland, Cal., has just been completed. This addition consists of a 4050-horsepower Hamilton Corliss engine which is direct-coupled to a 2700-kilowatt General Electric interpole generator; new boilers, feed pumps, condensers, etc., have also been installed. The boilers will carry a steam pressure of 200 pounds per square inch.

This engine is said to be the largest of the Corliss type in service on the Pacific coast. It is of the horizontal cross-compound condensing type, having tail rods on both the high- and low-pressure sides; the low-pressure piston rod is forged hollow. The cylinders are 42 and 86 inches in diameter by 60 inches stroke. The steam pressure at the throttle is 175 pounds per square inch and a vacuum of 26 inches will be maintained. The engine will run at 75 revolutions per minute. It is expected that this engine will consume 11 pounds of steam per indicated horsepower per hour with conditions existing in the Oakland station.

Both the high- and low-pressure valve gears are operated by double eccentrics and all steam and exhaust valves are double ported. The valve gear is of the new Hamilton Corliss gravity type, which is guaranteed to operate at speeds up to 175 revolutions per minute. The flywheel is of the built-up segment type, 22 feet in diameter and weighs 200,000 pounds.

Some idea of the magnitude of this engine can be had from the accompanying illustration, which is that of the low-pressure cylinder. It weighs 50 tons and is made of semi-steel.

Low-pressure Cylinder of 4050-horsepower Corliss Engine, Weighing 50 Tons

Novel Features of Mine Power System

By C. A. Tupper

The new power plant of the Ray Consolidated Copper Company, at Hayden, Ariz., contains four horizontal four-cylinder triple-expansion engines, the largest of their type ever constructed.

The hoist at the mine also is of novel design.

Much attention has been attracted by the new steam power plant of the Ray Consolidated Copper Company at Hayden, Ariz., which supplies power for operating the mines and the 10,000-ton concentrating plant recently erected at that place.

Four engines have been installed (see Fig. 1), the largest of the type ever constructed. These are horizontal four-cylinder triple-expansion Corliss engines, with 28-inch high-pressure, 52-inch intermediate and two 54-inch low-pressure cylinders, all having a common stroke of 48 inches. The low-pressure cylinders are bolted directly to the frames, and the high and intermediate cylinders are placed tandem to the low-pressure cylinders. The distance pieces between the low-pressure and the high- and intermediate-pressure cylinders are of heavy

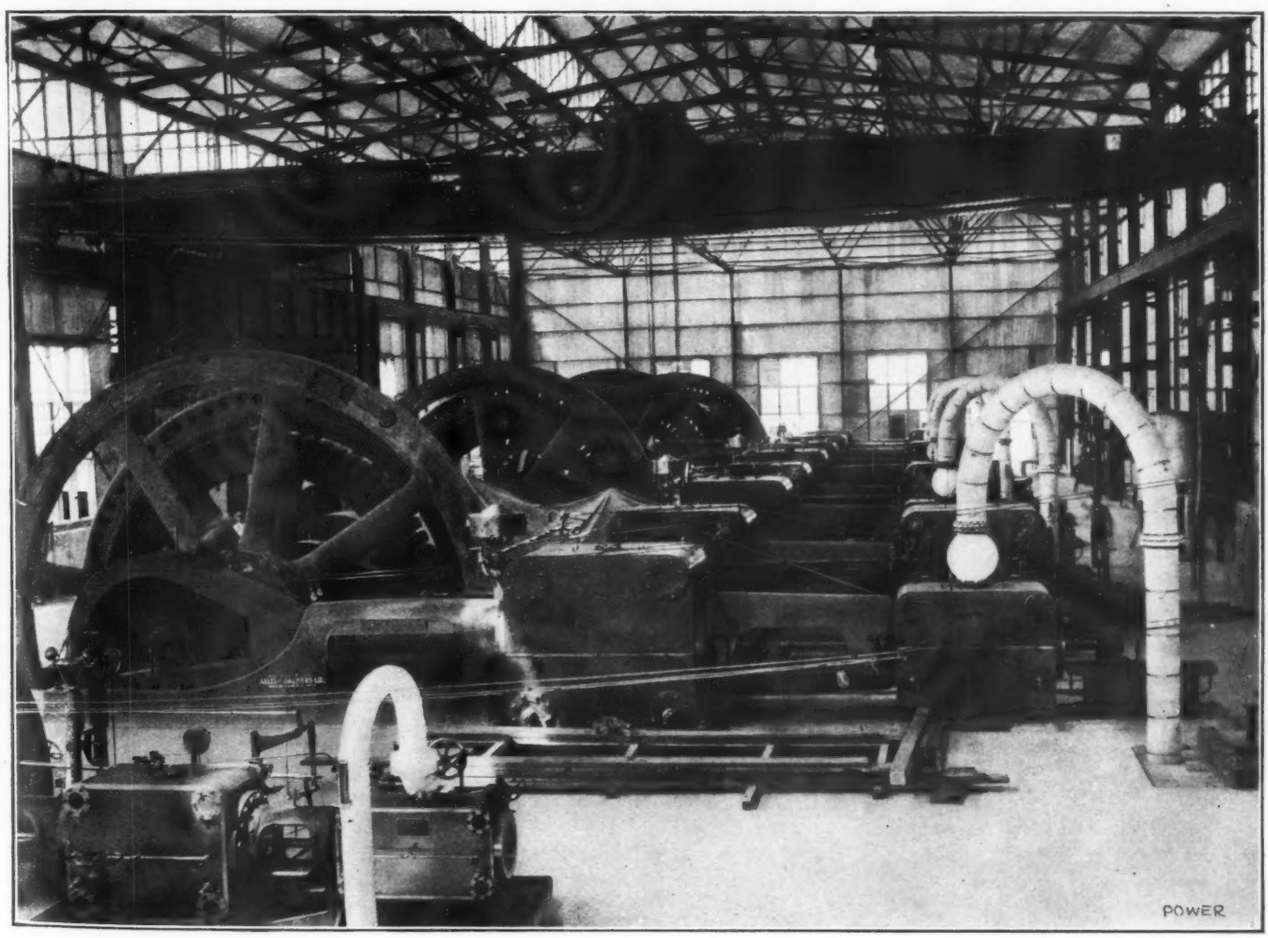


FIG. 1. GENERAL VIEW OF ENGINES

construction and are split horizontally so that, by taking out the tap bolts holding the distance pieces to the cylinders, these parts can be removed, the intermediate crosshead taken out, the low-pressure cylinder head removed and the low-pressure piston taken out. The tail guides, after being properly lined up, are doweled in place so that they can be removed when necessary to open the cylinders and can be accurately put back by replacing the taper dowel pins in their respective holes.

The piston rods on these engines are made unusually large and rigid so that they practically carry the weight of the pistons. This method of construction is the same as that employed in gas-engine practice and has proved very successful. Both the cylinders and frames are of entirely new design, and the frame and guides are made in one casting with a lip cast around the base to catch any oil which may run down the sides. One of the most striking features of the frame is the massive jaw which retains the shells carrying the shaft. The bottom shell is made circular in form so that it will aline with the shaft under all conditions.

The quarterboxes are adjustable with wedges, both fore and aft, adjusting bolts being brought up through the top of the cap and so arranged that the quarterboxes can be taken up while the engine is running at full speed.

The crosshead guide and crank are entirely inclosed with steel oil guards and the front is provided with wire-screen doors, which prevent the oil being thrown out and at the same time allow air to enter for circulation and to assist in keeping the pins cool.

The full-load rating of each engine is 2650 horsepower when receiving steam at 175 pounds gage and 50 to 75 degrees

superheat; but they are designed to handle heavy overloads, as shown by the fact that for over three months after installation the first two engines ran noncondensing and the load frequently swung to 2500 kilowatts. Although the normal rating of the generator is 1750 kilowatts with 80 per cent. power factor, the engine carried this load with only 150 pounds steam pressure, which was a remarkable performance for triple-expansion engine running noncondensing.

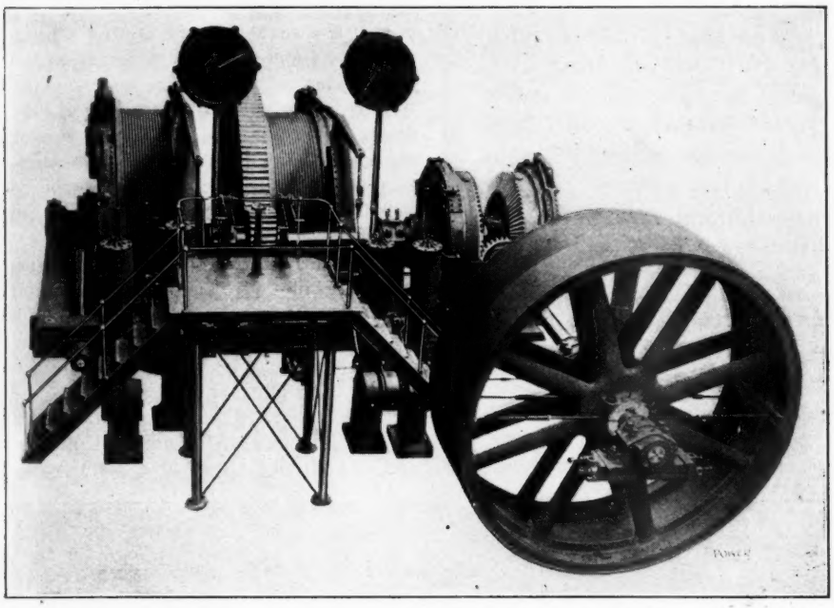


FIG. 2. MAIN HOIST AT MINE

The flywheels are 26 feet in diameter, weigh 55 tons each and are made from steel castings on account of the high rim speed corresponding to 100 revolutions per minute.

Each engine drives a three-phase, 60-cycle, 6600-volt generator excited at 120 volts from a 60-kilowatt direct-current engine-driven generator. These units, complete, were built and installed by the Allis-Chalmers Company.

Steam is supplied by fourteen Heine boilers of 513 horsepower each, equipped with Foster superheaters. The feed water is delivered by four compound Blake pumps, through three Foster feed-water heaters. The hot water from the condensing system is pumped to three cooling towers, constructed on what is known as the "Ray Consolidated system," and thence returned to an 8,000,000-gallon reservoir which feeds both the power plant and the mill. All of the water circulated is handled by a Nordberg triple-expansion pumping engine of 10,000,000 gallons capacity per 24 hours. The original source of supply is the Gila river, where three motor-driven pumps are installed.

Current from the generators is supplied to motors operating machinery in the ore-reduction mill, repair shops, etc., and is also transmitted at 45,000 volts to the company's mines at Ray, 20 miles distant. Here the features of the power system center about the hoisting plant.

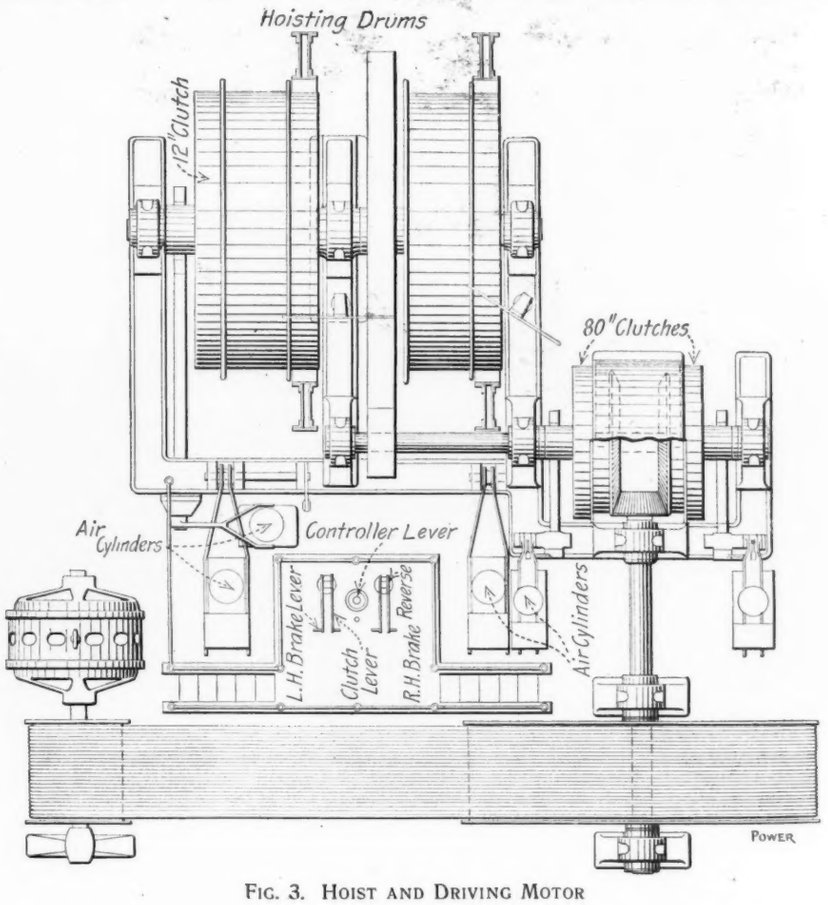


FIG. 3. HOIST AND DRIVING MOTOR

The principal unit consists of a Wellman-Seaver-Morgan hoist for lifting in balance a net ore load of 12½ tons, a skip of 8 tons and a rope of 3 tons from a depth of 5000 feet at a speed of 300 feet per minute. The hoist is driven through a rope drive by a 300-horsepower three-phase, 440-volt motor, the latter fitted with a 44-inch pulley having grooves turned for thirty-two 1-inch ropes which drive a 13-foot pulley on the pinion shaft of the main hoist.

The object of this design is to have the hoist motor operate continuously in one direction, while the drums may be started, stopped or reversed. One cause of electric loss in hoists operating by alternating-current motors is occasioned by the starting of the motor, which when the motor is large, becomes serious. It is, therefore, desirable not to be obliged to start the motor at each trip, since when the motor is running idly the current required by it is limited, so that the peak losses are very materially reduced. In this type of hoist the load is gradually accelerated by applying a powerful clutch.

As shown in Figs. 2 and 3, the power is transmitted from the large pulley to the hoist by means of a bevel-gear driving and reversing system. The pinion engages in two cast-steel, machined bevel gears running in opposite directions. Both these gears are loose on the shaft, while on the back of each is a friction ring with which the band-friction clutch engages. The clutches are securely keyed to the intermediate shaft, and are

set by weights and released by the operating cylinders. These cylinders operate on compressed air taken from the air mains supplying the mine, but there is an auxiliary motor-driven air compressor in the engine house which works automatically in such manner that when the air is up to 100 pounds current is shut off from the motor, and when the pressure drops to 80 pounds, the motor is started again. Both of the clutch-operating cylinders are worked by a single lever on the operating platform and are so connected that either clutch may be thrown in at will; but both clutches can never be in at the same time, and one clutch must be wholly thrown out before the other can be thrown in. With the motor running continuously in one direction and connected by means of the bevel gears to the hoist, it is possible through the operation of these clutches to start, stop and reverse the hoist.

The intermediate shaft is extended and fitted with a pinion which engages in the main driving gear for the two drums. This gear is approximately 16 feet in diameter. The drums are 12 feet in diameter and are grooved to carry about 600 feet of 1⅛-inch hoisting rope. The loose drum is fitted with a powerful band-friction clutch of the modified Lane type. This is of massive proportions, with a 12-foot driving ring, and is built for a possible working load of 50,000 pounds. Lifters are provided for equalizing the distance of the bands from the clutch ring when the clutch is released. Each drum has a powerful post brake.

The brakes, as well as the main clutch, are each operated by means of a combined air and oil cylinder fitted with a floating valve gear under control of a lever on the operator's platform. Dial indicators are provided, one being driven from each drum for showing the position of the skip in the shaft.

The skips are not provided with safety dogs or appliances, on account of the extreme weight and bulkiness of such equipment for a load of this magnitude, but an overwinding device prevents the skips from being carried into the sheaves through any neglect on the part of the operator. This device consists of two limit switches, one for each skip, so placed that when the skip is carried beyond the highest point for dumping, it will come in contact with an extended lever fitted with a roller, which lever, moving through an arc of 35 degrees, disengages the contacts. These limit switches are connected by wires to solenoids operating quick-opening valves in the supply pipes to the air cylinders, so that if the skip passes a given point in the shaft, the solenoids come into action and at once release the pressure from the operating cylinders, allowing the weights to apply both the powerful brakes and throw out the clutches, bringing the hoist at once to a stop without the necessity of stopping the motor.

Flywheel Explosion, Farmington, Utah

By William E. Piper

Due to the racing of the engine, an 18-foot flywheel exploded, tearing holes through the roof and the end of the building. No one was injured.

On the afternoon of September 14, a disastrous flywheel explosion occurred at the Farmington plant of the Salt Lake & Ogden Railway Company. Owing to lack of definite information, however, the account of the accident has been withheld until the present issue.

The plant, which was recently put in operation, contains one 500-horsepower and one 750-horsepower Allis-Chalmers compound-condensing engine, each connected through a belt drive to a 400-kilowatt alternating-current generator.

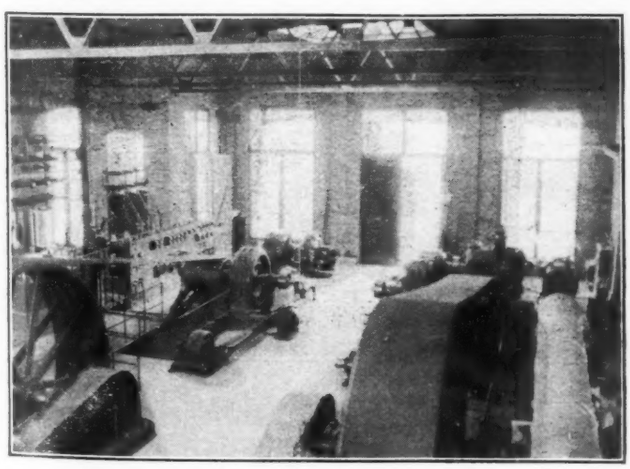


FIG. 1. ENGINE ROOM AS IT APPEARED BEFORE THE EXPLOSION

FIG. 2. SHOWING HUB OF FLYWHEEL AND DAMAGE DONE TO ENGINE

These units are shown in the general view of the engine room, Fig. 1, taken a few days previous to the accident. There are two exciters, one motor-driven through a belt and the other a steam-driven direct-connected machine, shown at the extreme right of Fig. 1, just beyond the large unit.

The engine of the latter unit had an 18-foot flywheel built up in four sections. This is the wheel which exploded. The hub of one-half the wheel remained on the shaft, as shown in Fig. 2, while the other broke out at the bolt holes and dropped into the basement. Fig. 3 shows the wheelpit after the explosion. Fragments of the rim and bolts were hurled in all directions, some breaking through the roof, as shown in Fig. 4, and another large piece passing through the end of the building (see Fig. 5) and continuing slightly upward until it entered the side of a barn nearly 400 feet distant; it then passed through the barn, out the other side (see Fig. 6) and landed at the base of the old apple tree, shown in Fig. 7.

The universal rod on the governor, connecting the valve gears of the high- and low-pressure cylinders, was broken and several of the pins on the valve gear

were bent; otherwise, little damage was done to the engine. The receiver, however, was overturned and a hole made in the oil separator; also, the pipes leading to the receiver from the high-pressure cylinder and those leading from the receiver to the low-pressure cylinder were broken in several places.

Just prior to the accident the engineer was standing by the steam-driven exciter, which was being cut out, the excitation load being thrown upon the motor-driven exciter. It is supposed that the latter failed to excite; thus the load was entirely shut off. An instant later the explosion occurred, causing the damage illustrated.

When the engine first started to race there were three or four men on the roof of the building, but feeling the vibration as the speed of the engine increased, they started down just in time to reach a place of safety. At the switchboard in front of the engine there were standing the manager's son, the chief electrician and the substation operator, but each escaped without injury.

Half a Billion Tons of Coal

According to a recent bulletin of the United States Geological Survey, the combined production of anthracite and bituminous coal and lignite for 1910 reached the unprecedented figure of 501,576,895 short tons, with a spot value of $629,529,745.

This is the first time in the history of this country that its coal mines have exceeded half a billion tons. This great output, according to E. W. Parker, the Survey's statistician, was attained in spite of the fact that most of the mines in Illinois, Missouri, Kansas, Arkansas and Oklahoma were closed for nearly six months by strikes.

The largest increases in production were in those States which benefited from the idleness of the miners in the Mississippi valley. As showing the largest increase, Pennsylvania ranked first, West Virginia, Ohio, Kentucky, Indiana and Alabama following in order named.

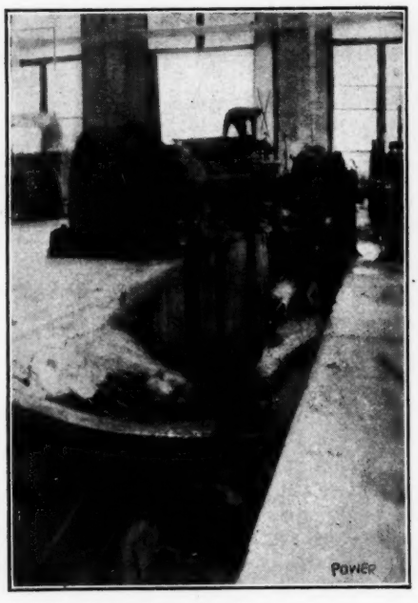


FIG. 3. WHEEL PIT

FIG. 4. HOLES IN ROOF

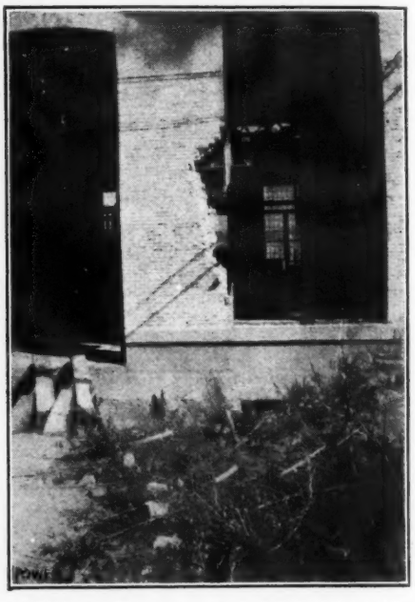


FIG. 5. HOLE IN END OF BUILDING

FIG. 6. BARN AFTER PIECE OF RIM HAD PASSED THROUGH

FIG. 7. SECTION OF RIM AT BASE OF TREE

dropped on the engine and the governor did not control the steam. By the time the engineer had closed the throttle on the exciter unit and had reached the throttle of the runaway engine, the latter had gained considerable speed. The throttle valve had been newly packed and turned hard. Seeing the speed of the engine increasing so rapidly, the engineer deemed it advisable to protect himself and ran to safety before the steam

Before being installed in the present plant the engine had been in service almost continuously for six or seven years at another plant. It might be remarked that in the former installation it was found necessary only to give the throttle wheel a spin, from which it would close itself, and unless the attendant checked it the valve often became set so that it required the combined efforts of two men to open it.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Rewinding a Direct Current Generator

By R. H. Fenkhausen

It is very probable that engineers located near the larger electrical manufacturing centers do not realize their advantage over those on the Pacific coast. The Eastern engineer has only to decide what special type of apparatus is required for a given motor application and delivery can usually be obtained from the factory within a few days.

The great diversity of demands in the electrical industry makes it impracticable for the manufacturers to carry a full stock of special apparatus in all the large cities, so that the Western engineer is usually forced to adapt to his needs the standard apparatus available in the local stock, or else wait several weeks for delivery from the factory.

It frequently happens that special electrical processes must be placed in operation at the earliest possible date, and instead of ordering the apparatus best suited to the process in hand, the designing engineer must first ascertain what machinery is available locally, and design his other apparatus to suit the speed and other characteristics of these machines. It is this handicap of distance which forces the Western engineer to adopt some of the peculiar engineering expedients which often startle the Eastern visitor to the Pacific coast. The fact that efficiency is sometimes sacrificed should not detract from the ingenuity of the application, because it is hardly necessary to call attention to the careful study required before the available apparatus can be made to give even moderately satisfactory results.

Lack of suitable machinery often compels the engineer to rebuild a standard machine, sometimes at a cost greater than that of a new machine. Rebuilt machines are quite common in the West, and they often puzzle the original manufacturers from whom repair parts are ordered after the machine has changed hands. The new owner does not always recognize the special character of the machine and orders repairs as per the serial number on the nameplate, occasionally with startling results.

The manufacturers themselves are sometimes guilty in this respect, as the writer found to his inconvenience on two occasions. In one instance several motors of a given type were ordered and supplied from local stock by the manufacturers, nothing being said about the machines having been rewound in their local repair shop. The nameplates had been changed for new ones but the factory serial number was stamped on the new plate, with the result that a new set of coils ordered some years later were not suited to the machine, and the truth only came out after much wrangling and loss of time.

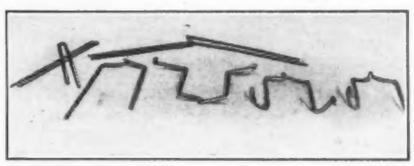


Fig. 1. Various Shapes into Which Windings Were Bent

A rather unusual problem of rewinding came before the writer, last year. A 65-volt, 450-ampere, direct-current generator with a speed of 1120 revolutions per minute was required at short notice for some special electrolytic research work, and no standard 110-volt machine of the proper characteristics was available locally. A 450-ampere, 110-volt machine could have been run at reduced speed and separately excited, but there was no such machine to be had.

After some preliminary calculation it was decided that a 20-horsepower, 220-volt motor frame already on hand could be altered. The only doubtful point was the ability of the commutator and brushes to carry six times their rated current for 15-minute periods, but it was figured that this could be accomplished by using wider and thicker brushes and directing a current of air from an electric fan onto the commutator.

The original winding was of the progressive-wave type, with 94 coils (one idle) arranged two per slot and connected to a 93-bar commutator. Each coil consisted of two turns of No. 10 wire, the two turns being in parallel.

The new winding was also of the progressive-wave type, but had only 47 coils, one per slot, and required a 47-bar commutator. Each coil consisted of one turn of No. 2 wire. It was intended that copper strap coils be used, but a canvass of the local market revealed nothing suitable; even the No. 2 wire finally adopted was bare, hard-drawn trolley wire which had been left over from the cranes and had to be annealed before using.

The various steps in the process of bending the coils are shown in Fig. 1. and the special tools used are illustrated in Fig. 2.

The wire was first bent into two concentric U-shaped loops, shown crossed at the left of Fig. 1. These loops were formed by bending the wire around the forms shown at *a* and *b*, Fig. 2, and squeezing in a vise. The hooked ends of the forms held the wire in close contact with the form and prevented distortion of the loops. The sizes of the two loops were such as to permit the insertion of cotton insulation between them.

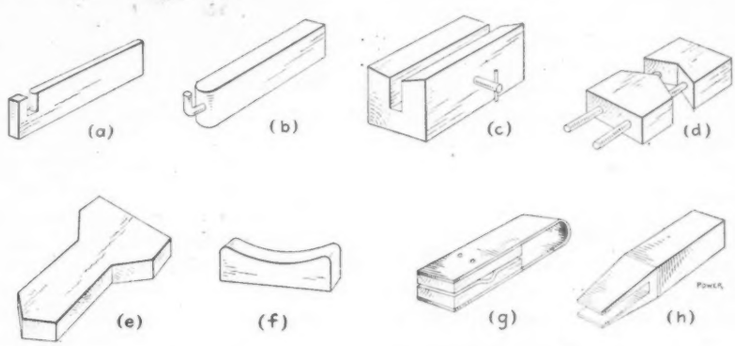


Fig. 2. Tools Used in Bending Windings

The two loops were then "nested," placed in the tool shown at *c* and pulled

out into the shape shown at the top of Fig. 1, the slanting surfaces of the tool being used to give the proper angle to the coils.

The tool *d* was next clamped between the jaws of a vise and the coils bent to conform to the wooden templet *e*, as shown in the center of Fig. 1, each bend being marked off from the templet in turn. As the end connections of the coil had to span half the circumference of the armature, it was necessary to

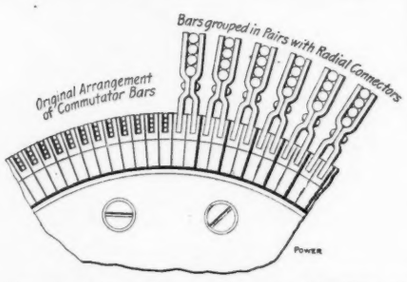


FIG. 3. ORIGINAL AND FINAL METHOD OF ATTACHING WINDINGS TO COMMUTATOR

bend them approximately to the form of a semicircle. A hardwood saddle *f* was cut out to the proper radius on a bandsaw and the end connections were shaped to it with a fiber mallet, after which cotton sleeving was slipped over each coil and given a coat of varnish to hold it in contact with the copper.

The original winding had a cross-section of

$4 \times 10{,}404 = 41{,}616$ *circular mils*

whereas the cross-section of the new winding was

$4 \times 66{,}564 = 266{,}256$ *circular mils*

It will be noted that the amperage capacity is six times as great, while the voltage is decreased to only one-quarter of its original value, which is equivalent to a 50 per cent. increase in capacity for the same speed. This increased capacity was possible on account of the extra copper, in the space formerly occupied by the insulation between turns. Had rectangular copper been available, 20 per cent. greater capacity would have been possible.

COMMUTATOR CHANGES

The most difficult problem was the commutator, as only 47 bars were required instead of 93, and the necks were too thin to slot for No. 2 wire, even had it been possible to bend the wire down to the bars. Hence the method shown in Fig. 3 was adopted. The commutator was dismantled and an extra bar was made of busbar copper and carefully filed to the exact shape. Each mica segment was then slightly skinned until enough mica had been removed to make room for the new bar. As the latter was only 0.25 inch thick and there were 94 mica segments, it was necessary only to remove an average of about 2½ mils from each segment. The new bar was made with parallel sides and not tapered like the other, because it replaced mica which was parallel.

The commutator was then reassembled with the copper and mica segments in pairs, the copper surfaces between the bars of each pair being rubbed to a perfect surface on fine sandpaper glued to a true surface plate.

Radial necks were made from 1/16x1-inch copper and pressed into shape with the tool *g*, Fig. 2. This tool was also drilled to serve as a jig for drilling the rivet holes in the necks. The copper strips were riveted back to back in pairs and after being tinned all over were sweated into the original wire slots in each pair of bars, as shown in Fig. 3, making a soldered connection between each pair of bars through the neck, in addition to the contact between the bars themselves. As the necks came up flush with the outside of the core, the coils came straight out to the necks, and, being on a much larger circle, left ample room between necks for ventilation and insulation.

Insulating cells were placed in the armature slots, and the coils were inserted and soldered, after which the bonding wires were replaced and the commutator turned.

Owing to the large amount of metal to be heated at the point where the leads were soldered to the commutator necks, it was necessary to use a heavy electric soldering iron, with a tip slotted to fit the neck, as shown at *h*, Fig. 2.

The original brushes were ½ inch, but the doubled bars allowed the use of a 1-inch brush, and in making the holders for the new brushes the width was increased about 25 per cent., as the full width of the commutator was not covered by the old brushes.

When the machine was finally completed, the field was separately excited from the 220-volt power circuit and the machine was given a full-load test together with its driving motor. The results excelled the expectations, as 300 amperes were carried with ease and 450 amperes could be carried for about 30 minutes by using an electric fan to cool the commutator. There was no perceptible sparking, but the heating of the commutator became so great after a 30-minute run as to almost melt the leads out of the bars.

As 15 minutes at 450 amperes was all that was required, no trouble was encountered and although it cost considerable money to rebuild the machine, the cost was only a fraction of the probable loss had it been necessary to wait for a new machine from the factory.

In large bar-wound machines having conductors over ⅛ inch thick it is customary to use several thin bars, connected in parallel at the commutator, but insulated from one another throughout their length, to cut down the eddy-current loss in the copper. It was feared that No. 2 wire would give trouble from this source when used on a comparatively small armature such as the one under consideration, but although the eddy-current loss was present as shown by the no-load tests of the machine, it did not seriously affect the capacity and the machine was in daily use up to the end of the writer's connection with the company for which it was designed.

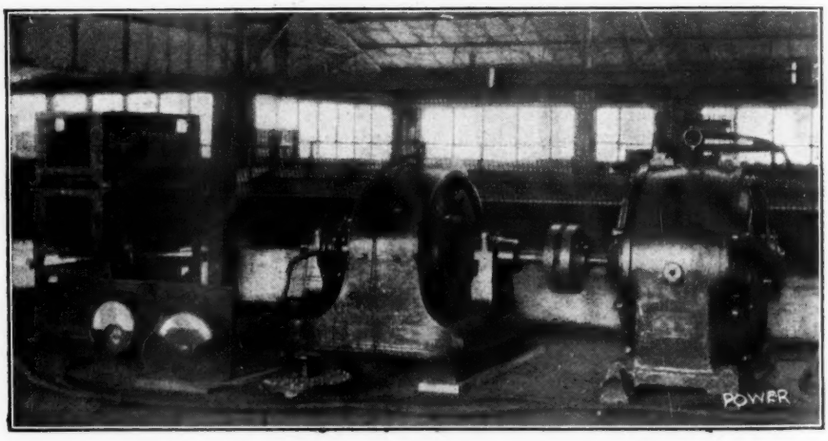


FIG. 4. MACHINE AS IT APPEARED AFTER REWINDING

Fig. 4 shows the machine coupled to its driving motor, and it will be seen that there is nothing unusual about the appearance of the installation.

A factor which militates against the success of Chinese industrial undertakings is their dislike of employing foreign engineers. The Chinese are quick to see the industrial and commercial advantages in the Western way of doing things, but, as in plants and factories, they go to great expense in erecting an uptodate plant and installing machinery; then they discharge the foreign expert almost as soon as the machinery can be started and when anything goes wrong they are helpless.

LETTERS

Mr. Ropeter's Comment on Mr. Edge's Wiring

In the October 10 number, Mr. Ropeter criticizes my article on "Wiring Pointers" in which one snap switch is shown controlling eight lamps, saying that the fire underwriters will not allow more than three lamps on one snap switch. This statement really has no meaning, because the underwriters' requirements are expressed in amperes or watts, and not lamps; it is possible to put one lamp in a circuit that will require as much current as eight regular lamps.

Further, I would refer him to the following statement on page 40 of the underwriters' rules:

"Up to 250 volts and 30 amperes approved indicating snap switches are suggested in preference to knife switches

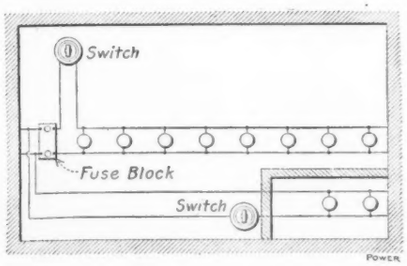


FIG. 4

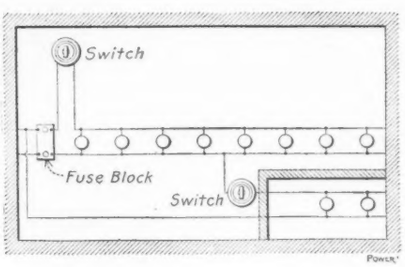


FIG. 5

on lighting circuits." This makes it possible to control one hundred and twenty 16-candlepower lamps with one snap switch. Of course, this means a double-pole snap switch, but nevertheless it is a *snap* switch. Directly beneath the suggestion quoted is the rule: "Single-pole switches may be used in two-wire circuits supplying not more than 660 watts." This rule enables one to control twelve 16-candlepower lamps with one single-pole snap switch.

The connection of the two-light circuit in Figs. 4 and 5 is a mistake in the drawing; the circuit should start from inside the fuse block, so as to be protected by the fuses.

Regarding the paragraph on grounding conduit being restricted and vague, I would say that this paragraph was cut short purposely, because I took it for granted that all engineers understood such a simple thing as grounding a pipe and if they did not they could easily find out by referring to the fire-insurance code of rules and regulations.

WALTER C. EDGE.

Philadelphia, Penn.

Referring to Mr. Ropeter's criticism in the October 10 issue of Mr. Edge's wiring diagrams, I beg to say that the underwriters allow single-pole switches to control circuits carrying 660 watts or less, and Mr. Edge's circuit had but eight lamps which would require only 448 watts, with carbon filaments, and much less with tungsten. Moreover, on page 40, section 22 (b) of the "Underwriters' Rules," it is suggested that up to 250 volts and 30 amperes improved indicating-snap switches should be used in preference to knife switches on lighting circuits. As to the two-light circuit without fuses, that would be all right providing the size of the wire to the two lamps was the same size as that in the other circuit, and fused rosettes were used, which could be done because No. 14 wire would be large enough for all requirements in this case.

WILLIAM T. GARLITZ.

McKees Rocks, Penn.

Failure of a Generator Due to a Swinging Open Circuit

Recently the writer had an experience with an alternating-current generator that may prove of interest to others because of the unusual and baffling conditions existing, which obscured the real trouble and had everyone guessing for a while.

The machine was a little alternator delivering single-phase current at 110 volts and 60 cycles. It was an old type of machine with a stationary field magnet and a revolving armature. The wires connecting the winding to the collector rings were soldered to lugs on the back edges of the rings.

The machine refused to generate on several occasions before the trouble was located, and the electrician reported that each time the machine had refused to show any voltage, after tinkering with it a while it had "built up" all right without any apparent cause. He also said that he had tested the armature and field circuits with a magneto and they had tested out entirely clear of grounds and open circuits.

Matters kept getting worse until one day the generator refused to build up its voltage and the usual tinkering failed to produce any results. The writer and the electrician went over all the connections and tested all the circuits, including the armature, with the magneto outfit. Everything was apparently all right, but the alternator still refused to generate any voltage.

After working around for half an hour we finally started the machine up, disconnected the outside circuit leads and attempted to ring through the armature direct from the two collector rings, but were unable to get a ring from the magneto. This could only be due to an open circuit, but we had just tested the armature standing still and the magneto had rung through all right. We shut the machine down and tested the armature again, standing still; the magneto rang through all right. We then started it up again, and the armature tested open. This, of course, could be due only to a swinging open circuit which swung open when the armature was running and closed when it stopped. Investigation with this in view soon disclosed the fact that the armature lead to the lug on one of the collector rings was loose. When the armature was standing still, this lead made contact with the lug but when the armature was rotating, centrifugal force caused the lead to fly away from the lug and open the circuit. After the lead was resoldered to the lugs the generator operated perfectly.

H. M. NICHOLS.

Kenyon, R. I.

Niagara and Victoria

What is the true comparison between the power of Niagara and the Victoria falls in South Africa? The answer is that the flow at Niagara varies between 62,000,000 and 104,000,000 gallons per minute; that at Victoria is as low as about 5,000,000 gallons in August.

The mean available drop at Niagara is 160 feet and at Victoria 380 feet. Hence, while the minimum Niagara flow represents about 3,000,000 horsepower, the Victoria flow in August represents only 580,000 horsepower, and, accepting the statements of local authorities that in November the flow at Victoria drops to only 2,500,000 gallons per minute, the minimum horsepower there can be only about one-tenth of Niagara's minimum. The maximum of Victoria is not given.—*Scientific American.*

Work on the construction of a power plant at the Yakt falls, 20 miles northwest of Libby, Mont., is to start at once, according to J. H. Ehlers, of Spokane, who recently visited Libby on business in connection with the beginning of operations on the project by the Milwaukee Power Company. The plans and specifications for the plant have been completed at a cost of $10,000. It is the intention to develop 3400 horsepower in two units of 1700 horsepower each. A portion of the electric power generated will be used by the Lincoln Gold Mining Company, which owns the Sylvanite mines.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Flywheel Wreck at Hagerty Shoe Factory

During the forenoon of October 24, two 72-inch flywheels of a 35-brake-horsepower producer-gas engine, belonging to the Hagerty shoe factory, of Washington Court House, O., separated, badly injuring the engine operator and wrecking the engine, but causing very little damage otherwise.

The unit is of the four-stroke-cycle type with poppet inlet and exhaust valves and auxiliary exhaust port, which is uncovered by the piston on reaching the crank end of the stroke. The engine is a 14x24-inch with forged crank shaft 5 inches in diameter and crank pin 6 inches in diameter by 5 inches long. To the left flywheel (estimated weight about 2000 pounds), was bolted the driving pulley for belt connection with a clutch pulley on the line shaft at the rear of the engine, shown in Fig. 2.

The unit, which had been in service about four years, was installed to operate on producer gas, developing 35 brake horsepower at 190 revolutions per minute, and at the time of the accident was running on a mixture of natural and producer gas.

On the morning of the accident the engine was started at about 6 a.m. and ran smoothly until about 8:30 a.m., when those working near heard an unusual sound like that of scraping or grinding going on in the engine. There was no indication of an increase in speed on the part of the engine. The operator had just stepped from the producer room to a position near the cylinder head, when the flywheel on the left side let go, immediately followed by the wheel on the right. The engineer had no recollection of just what happened after stepping through the producer-room door, but when found he was lying across the air-supply line with a rim section of the right wheel, weighing about 800 pounds, resting upon him. This rim section, shown at the left in Fig. 1, was of about 160 degrees and clear of arms. It struck the basement wall, causing some damage, and then rebounded, catching the engineer. In its flight it tore away the producer- and natural-gas connections and the air-supply line, destroying the governor mechanism and displacing the inlet-valve box as shown in Fig. 1. A section of the left-hand flywheel tore away the double-exhaust connection which ran horizontally from the engine cylinder and connected to a vertical exhaust line, shown in Fig. 2. Some part of this wheel also struck the clutch pulley on the line shaft, knocking out a section of its rim.

A 12x12-inch wooden girder, located just to the front of the engine, of 15-foot span and supporting the floor above, was struck by each flywheel, displacing it 4 inches horizontally.

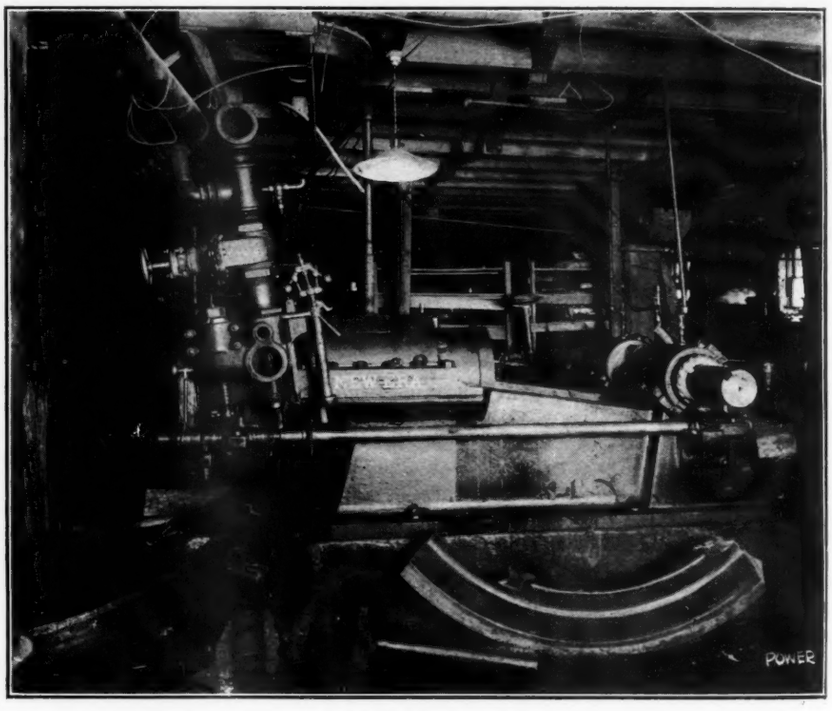


FIG. 1. INLET-VALVE BOX DISPLACED AND BOTH FLYWHEELS SMASHED

Each wheel rim broke into three pieces and of the 12 arms belonging to the two wheels, only one remained connected to a wheel-rim section. Each of the hubs, which broke into several pieces, fractured parallel with the shaft and in each case one of the fractures followed the keyway.

Each keyway of the shaft was carried forward in the direction of motion so that the metal of the shaft was raised and the width of the keyway at the top increased by ⅛ inch for the belt-pulley side and ¼ inch for the right-hand side. The enlargement of the keyway may be seen in Fig. 1. This change in dimension of the keyway indicated a movement forward on the shaft by the flywheels, placing the keys in shear and the hubs in tension, this movement being greater on the right side than on the left, due to the pull of the driving belt.

With the exception of the keyways, the crank shaft, the crank pin, connecting rod, main bearings, bed and cylinder seemed to be in good condition.

An examination of the piston and rings disclosed several new indentations on the face of the piston, a small section of metal broken from the edge of the piston face exposing the first ring, and about 2 inches broken from the end of the first ring. This piston-ring end with several small pieces of cast iron were found in the cylinder crowded up against the cylinder head. The ring portion showed signs of having been under compression and shear, and, therefore, these facts with others cited above would indicate that in some way this piece of ring on breaking away got into the clearance space, jammed between the piston and cylinder head and produced suffi-

cient sudden retardation of motion of the crank shaft to compel the flywheels, their rims weighing about 1800 pounds and having a linear velocity of about 3500 feet per minute, to break and to be thrown from the shaft.

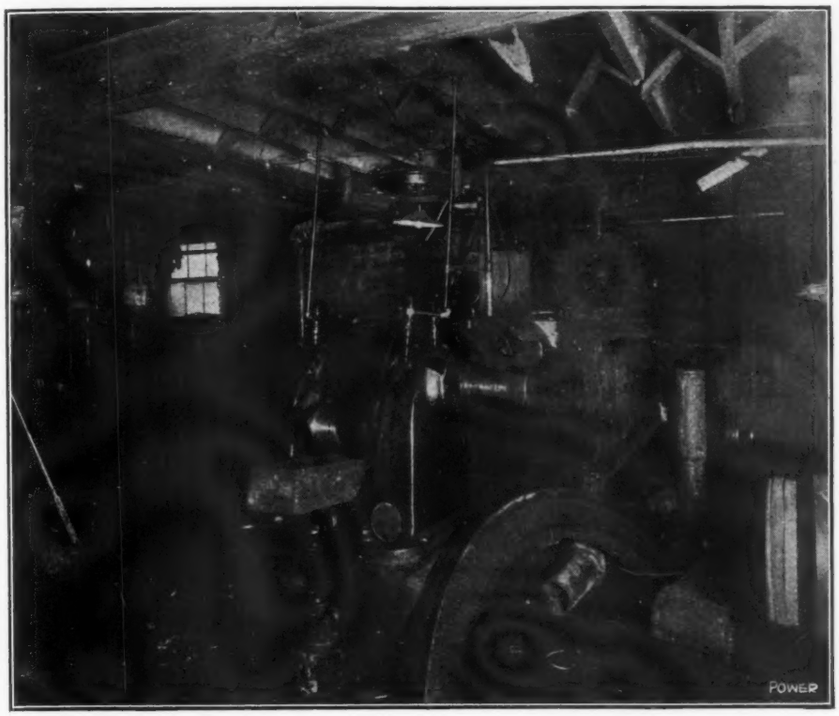


FIG. 2. CRANK END OF WRECKED ENGINE

Effects of Sulphur in Fuel Oil or Gas

BY OLAF OLAFSEN

Operating engineers have, no doubt, at times been puzzled to account for an occasional case of extremely rapid deterioration of pistons, piston rings and cylinder bores of whatever types of internal-combustion engine they may operate. The writer has often been called out to investigate such difficulties, sometimes only because the operator had discovered that the lubricating oil worked out of the open end of the cylinder in the form of a rusty sludge which was not unctuous in the least and had no "body."

One case of particular interest was that of a double-acting horizontal engine in which one cylinder wore more than ¼ of an inch in diameter in about three weeks. Another case was that of a smaller single-acting engine with a trunk piston in which the cylinder was enlarged 0.025 of an inch in about three weeks, although the engine was a new one.

The answer is simple: The cylinder walls in both cases were slightly porous and the cooling water oozed through very slowly but rapidly enough to combine with the sulphur in the fuel gas or the sulphur dioxide in the products of combustion, forming sulphurous or sulphuric acid which attacked the metal surfaces and also destroyed lubrication entirely, allowing the mechanical wear to proceed at an extremely rapid rate. Leaky cylinder-head packing will produce exactly the same results.

Another part which is affected seriously by this cause is the piston rod of a double-acting engine. Should a rod receive any water splash from the water-discharge tubes which are attached to the shoes, it will soon be corroded and the wear will become quite serious, often beyond the belief of those who have not had the experience.

A similar trouble is caused by cooling the pistons and rods of double-acting engines with water which is at too low a temperature. If the operator runs cold water through the rods they will "sweat" and the moisture will combine with the sulphur in the combustion products and produce what seems to be a mysterious cause of extremely rapid rod wear.*

Still another instance of this harmful influence is that of engines provided with splash lubrication in closed crank cases. Some of these engines are operated with a large amount of water in the crank case, the oil floating on the surface of the water, and when the engine is in operation they mix in a sort of emulsion which lubricates the reciprocating parts.

There is always more or less "blow" past the piston rings into the crank case during operation; consequently, the crank case is filled with oil and water vapor and products of combustion which have blown past the piston. This is the best possible condition for effecting the combination of water and sulphur dioxide and acid is soon formed; the crank shaft, especially at the finished bearings, is attacked; the finished parts become blackened and often eaten away to a considerable depth. For this reason, it is unsafe and indefensibly bad practice to use water along with the oil in the crank case of any internal-combustion engine using a fuel which contains sulphur.

Many Diesel engines are operated with water in the crank case but the operators are cautioned to have the fuel oil examined for sulphur and the use of water is prohibited if the fuel contains more than one-half of 1 per cent. of sulphur compounds.

City or illuminating gas contains considerable sulphur. Although the presence of hydrogen sulphite in city gas is explicity prohibited by law, all illuminating gases are allowed to contain from 150 to 300 grains of sulphur compounds per 1000 cubic feet and as the difficulty and cost of absolutely removing the sulphur from illuminating gas are great, it is morally certain that in practice the legal limit will be reached if not exceeded.

The natural gas of certain districts is free from sulphur but it is said that old wells, either gas or oil, give off a more sulphurous product than newly opened wells and it is well, therefore, to have the fuel tested for sulphur from time to time. The fact that a well once gave oil of a low sulphur content does not give any indication of how long it will continue to do so. Certain oil companies will furnish what they call a "desulphurized" fuel oil.

Producer gas, blast-furnace gas, or, in fact, any gas which is made by either a dry-distillation or partial-combustion process or both, is sure to contain enough sulphur to be troublesome in case of a water leak or with water in the crank case.

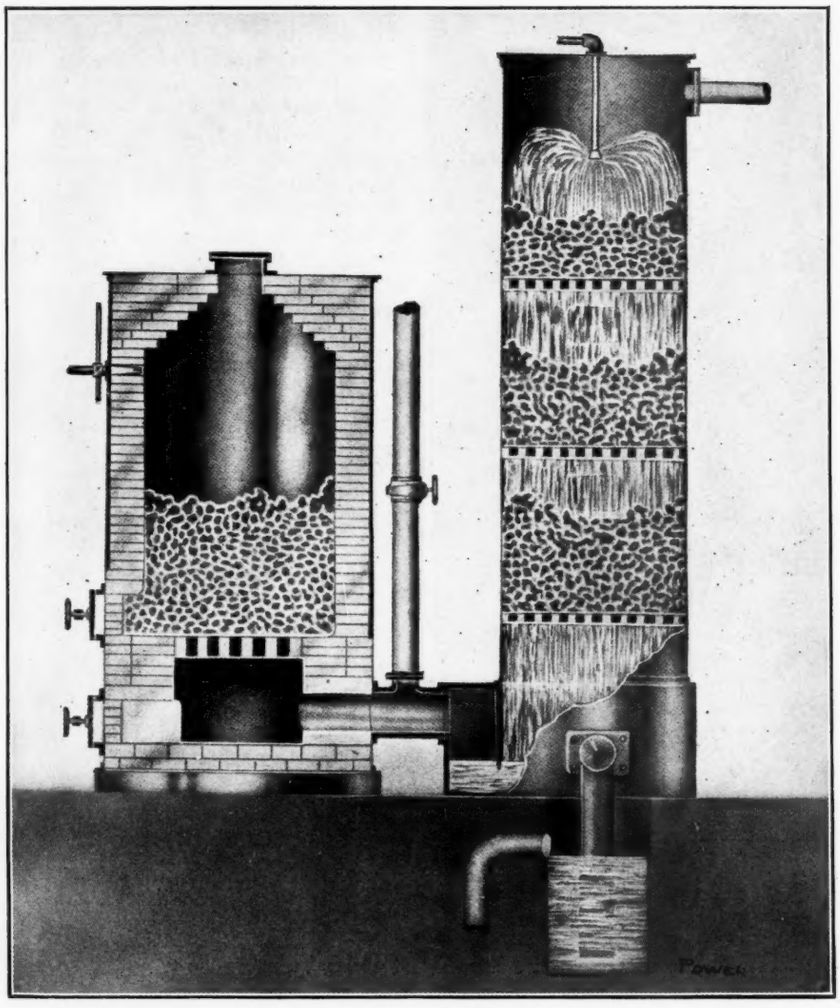
*This explanation of abnormal rod wear was suggested also by L. B. Lent, about two years ago.

The Grine Crude Oil Gas Producer

There was installed some time ago in the Fry pumping plant of the Union Hollywood Water Company (Los Angeles, Cal.) a gas producer using crude oil as "fuel" and operating on a principle different from that which usually forms the basis of operation of oil-gas producers. The oil is atomized in the upper part of the generator by means of a steam spray and there subjected to partial combustion. The products of this partial combustion pass downward through a bed of incandescent coke in the bottom of the generator and the heavy hydrocarbons are thereby "broken up," the tarry content is "fixed," and the portion of carbon which would ordi-

narily pass out as lampblack is deposited on the coke bed and replenishes the bed, partly making good the reduction due to gasification of the coke.

The accompanying sectional elevation of the generator and scrubber serves to indicate the simple construction of the former. The generator is about 4½ feet in diameter, inside, and 8 feet high. The coke bed in the bottom is maintained at a depth of between 3 and 4 feet. The reduction of the bed by gasification is very slow; the outfit under discussion supplies gas to a 100-horsepower engine running at practically full load, 24 hours a day, and the replenishment of the coke bed requires about 800 to 900 pounds a month—approximately one-eightieth of a pound per brake horsepower-hour.



GRINE CRUDE-OIL GAS PRODUCER

The provision of this bed of incandescent coke fulfils several conditions which are of importance in the gasification of crude oil. Commercial crude petroleum contains a small amount of earthy matter which is likely to be deposited in small openings and change the rate of fuel delivery, thereby affecting the quality of the gas and the rate of production. The coke bed tends to reduce the extent of such effects by serving as reserve fuel. Morever, such impurities as get into the generator, as well as the heavy hydrocarbons which ordinarily give so much trouble in the form of tar or lampblack, or both, are stopped by the coke bed. The heavy hydrocarbons are broken up, as previously stated, by the heat of the incandescent coke, the lighter portions being turned into fixed gases and the solid carbon liberated by the cracking process being deposited on the coke and subsequently gasified slowly instead of passing out as lampblack.

The gas is scrubbed and cooled in an ordinary tower scrubber containing water sprays and trays covered with coke, brick or other material for giving surface. Air for partial combustion is supplied at a low pressure by a positive blower, and oil is pumped from the reservoir and delivered to the burner under pressure by a small rotary pump. We are informed that the operation of the apparatus is simple and that no burning-out periods or periodic shutdowns for cleaning out are required.

The plant has been in operation nearly a year, the engine driving an Ingersoll-Rand air compressor which compresses air up to about 85 pounds gage pressure for pumping water by means of air lifts. The water, after being pumped to the surface by the air lifts, runs into a large cistern from which it is taken by a Dow duplex pump, also driven by the gas engine, and forced into the city mains.

The producer was designed by H. A. Grine, engineer of the Gas Power Machinery Company, Los Angeles, and Mr. Grine informs us that the Fry plant, using crude oil at 95 cents per barrel, or 2.3 cents per gallon, develops the same amount of power per gallon of crude oil that the ordinary distillate engine develops per gallon of distillate, which costs 7 cents per gallon in the same locality. The cost of power in this 100-horsepower plant, Mr. Grine states, is 0.76 cent per brake horsepower-hour, figuring fuel, labor, lubricating oil, waste, maintenance, depreciation, taxes and 7 per cent. interest on the investment.

Properties of Heavy Oils

Letters are frequently received by POWER asking for the composition, heat value, etc., of crude and other heavy oils used as fuel in oil engines. The properties of such oils vary over a considerable range, even for oils taken from the same field at different times, but the accompanying table gives what may be considered representative figures for the composition, weights and heat values of American oils.

PROPERTIES OF CRUDE OILS

Kind of Oil	Composition by Weight				Specific Gravity	Pounds per Gallon	B.t.u. per Pound	
	Carbon	Hydrogen	Sulphur	Oxygen			By Test	Computed
Ohio	0.834	0.147	0.006	0.013	0.800	6.68	19,580	19,718
Pennsylvania, light	0.820	0.148	0.010	0.022	0.816	6.80	19,930	19,519
Pennsylvania, heavy	0.849	0.137	.....	0.014	0.886	7.40	19,210	19,385
West Virginia, light	0.843	0.141	0.003	0.013	0.841	7.02	18,400	18,527
West Virginia, heavy	0.835	0.133	0.008	0.024	0.873	7.28	18,324	18,860
Texas	0.840	0.132	0.010	0.018	0.925	7.71	19,100	18,928
California	0.852	0.124	0.005	0.019	0.959	8.00	18,500	18,656

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Wire in Compressor Piston

One of the most peculiar compressor breakdowns with which I have come in contact happened recently in the plant in which I am operating.

The plant consists of one two-stage compressor, the cylinders being set on each side of a central belt wheel and the cranks set at right angles to each other. The power is furnished by a single-cylinder 90-horsepower gasolene engine.

One evening a severe knocking was noticed in the low-pressure cylinder on the crank end and the engineer in charge immediately shut down.

The following morning I took off the cylinder head, and upon removing the piston found a collection of what looked like headless ten-penny nails and a few small pieces of cast iron.

Upon replacing the piston and tightening the nuts which held it on the rod, the rod broke, showing it to be badly crystallized. It also cracked, due probably to the shock it had received the previous day.

A new rod was made and put in, but, before starting up, the intake piping was gone over so as to prevent any further scrap iron getting into the cylinder, although this was unnecessary as the intake was adequately protected by screens. Suspecting foul play, I left the intake open above the compressor in order to prevent anything being introduced from outside the building.

I then started up, but in about an hour I was forced to shut down as the low-pressure piston was knocking again on the crank end.

Imagine my surprise when, upon removing the cylinder head, I discovered another collection of scrap iron similar to the first. This was a puzzle and I lay off a day to thing it over.

While thinking over what I was up against, and wondering if the machine had turned into a scrap-iron factory, I noticed a small sand hole in the face of the piston. I poked into it and found that it went clear through into the core.

This explained the mystery; some of the wire used in reinforcing and supporting the core had not been removed, and as soon as the sand hole was large enough (about ⅛ inch) some of the pieces of wire had worked through into the cylinder.

As the piston walls were too thin to give a full thread I was forced to drill a hole through both faces of the piston and put in a staybolt, riveting both ends and finishing down flush with the piston face.

The small hole in the piston also lowered the volumetric efficiency of the compressor as it increased the clearance volume on that end an amount equal to the contents of the hollow piston.

The machine is again running properly. If any engineer has run up against this difficulty before, he has my profound sympathy, only I wish he had told POWER about it so that I would have been "next."

SAMUEL S. MURDOCK.

Bannock, Mont.

Substitute Trap Bucket

I came to my present position about two months ago and found one of the bucket steam traps on the high-pressure line leaking. I took it apart and discovered that the bucket, which was 4 inches deep and 6 inches in diameter, was badly corroded. I took a can 8 inches deep and 6 inches in diameter and cut it down to the same hight as the old bucket and then drilled a hole in the center of the bottom and put it in the trap. It worked satisfactorily until a new bucket was obtained.

P. J. MCENANEY.

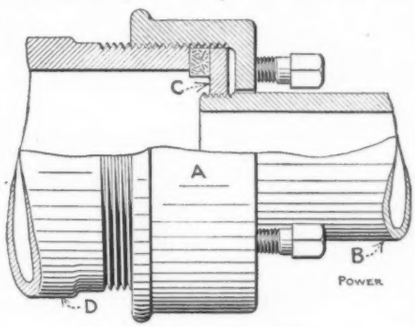
Menard, Ill.

Union for Tank Cars

The accompanying sectional illustration shows a union for connecting to the outlet nozzle of tank cars. It is attached to a long swinging length of pipe with a swing joint midway of its length, so that the cars do not have to be exactly placed before connecting to them.

The union consists of a 4-inch cap *A*, which is threaded loosely, so that it may be easily screwed on by hand. It has a hole drilled in it large enough so that the 2-inch nipple *B* may slide through it. There are also three holes tapped for ⅝-inch setscrews, which bear against the thin collar *C*, which is screwed on the end of the nipple *B*, and force it up against the end of the car nozzle *D*. The gasket between the collar *C* and the nozzle is rather thick to allow for poor alinement. This device does away with all pipe fitting, and the only tool needed is a small wrench to tighten the setscrews.

The coupling is first screwed on by hand and the gasket is then compressed by means of the setscrews. It is especially useful on cars in which the outlet nozzle is up between the car timbers or when the air-brake cylinder and truss rods are in the way, making it almost impossible to use a pipe wrench to tighten up the fittings to prevent leakage. The 2-inch pipe runs to the suction of a duplex pump, which discharges into the storage tank.



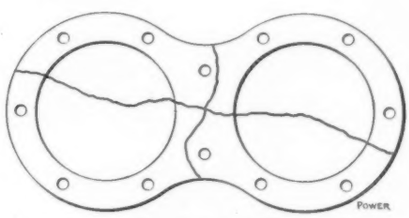
DETAILS OF UNION

S. M. DUNN.

Los Angeles, Cal.

Temporary Pump Repair

Once upon taking a job I found that the feed pump had been left full of water which had frozen in the water end and had cracked the cylinder head as shown in the sketch.



CRACKED CYLINDER HEAD

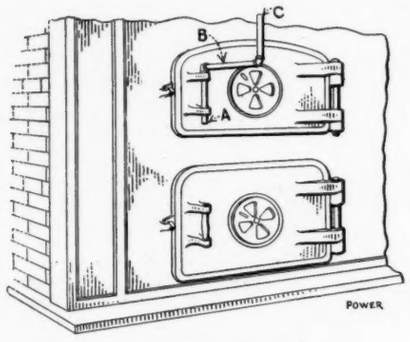
I got a piece of a leather belt large enough to cover the heads and, fitting this to the stud bolts, put the head back in place and ran the pump against 70 pounds pressure for 36 hours.

A. BLOM.

Chicago, Ill.

Handle for Furnace Door

Handles that have given satisfaction for the past seven months on the fire doors of a 300-horsepower water-tube boiler were made by inserting a piece of ½-inch iron pipe in the holes intended for the original wooden handle, as shown at *A*. A second pin *B*, 8 inches long, was connected to the first and a third piece *C* was connected as shown. This extension



HANDLE ON FURNACE DOOR

keeps the handle cool and saves several steps when about to renew the fires.

M. C. COOK.

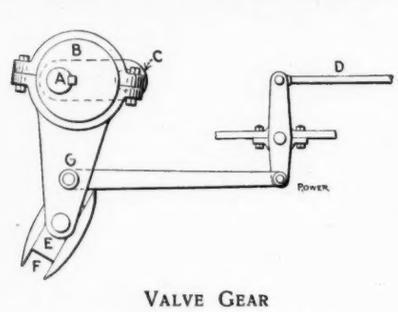
McCook, Neb.

Unequal Port Opening

I have a slide-valve, cross-compound engine of the traction-engine type. This engine has a valve gear as illustrated herewith, and owing to an accident it became necessary to reset the valves.

I found that the eccentric was keyed to the shaft, directly in line with the crank. After adjusting an equal amount of lead on each end, which in this case was $\frac{3}{32}$ inch, by turning the engine over I had about $\frac{3}{8}$ inch more port opening on the crank end than on the head end, although the point of cutoff was equal on each end.

Can any reader of POWER tell me how to adjust such a valve gear so as to get an equal amount of port opening on



VALVE GEAR

each end of the cylinder, and at the same time have an equal amount of lead, without rebuilding the valve gear?

When taking this matter up with the dealer who sold this particular engine he claimed that this was an excellent feature in valve gears, but he was unable to explain to my satisfaction the advantage of this feature.

What is the efficiency of such a valve gear? Would this be considered a practical engine?

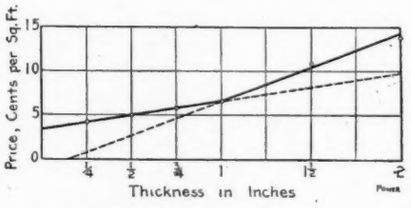
Referring to the sketch, *A* is the engine shaft, *B* the eccentric and *C* the crank. The valve rod *D* gets its motion by the combination of the sliding block *E*, in the link *F*, and the action of the eccentric, as it is connected to the eccentric arm *G*, between the eccentric and the sliding block *E*. The reverse is affected by simply slanting the link *F* in the opposite direction.

W. A. MUELLER.

Bath, S. D.

Purchasing Hair Felt

Persons having to do with the purchase of supplies may frequently find it to their advantage to use the graphical



SHOWING PRICE OF HAIR FELT AT DIFFERENT THICKNESSES

method to show the variation in price of different sizes, weights or qualities, as an aid in making an intelligent, economical selection.

To illustrate the idea, I have plotted the quotations received some time ago in reply to an inquiry about hair felt. In my case, it did not matter materially what thickness was purchased, as it was to be used for miscellaneous purposes. If too thick, a layer can be readily divided to any thickness desired. The prices were as follows:

Thickness, inches	Price, cents per square foot
¼	4¼
½	5
¾	6
1	6¾
1½	10¾
2	13¾

A glance at the plot which represents this quotation shows a remarkable difference between thicknesses above and below 1 inch. The heavy lines, representing the figures as quoted, cross on the 1-inch thickness, and it is obvious that one will get more of the material for the money by selecting 1 inch or thicker. The price for thicknesses less than 1 inch is expressed by the equation,

$$p = 3\frac{1}{2} + 3\frac{1}{4}\,t$$

and for thicknesses over 1 inch,

$$p = 7.3\ (t - 0.12)$$

where p equals cents per square foot, and t equals thickness, inches.

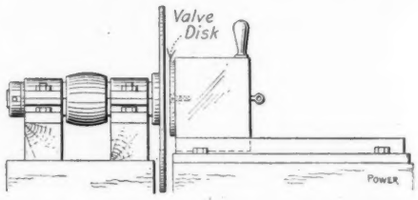
A. L. WESTCOTT.

Columbia, Mo.

Truing Up Rubber Pump Valves

I have a successful scheme for truing up rubber pump valves. Glue a piece of No. 2 emery cloth onto a steel disk that is mounted on a short shaft and is driven from any line shaft.

The valve is placed on the iron block, with the stud in the center. The guides are set square with the revolving disk.



RIG FOR TRUING RUBBER PUMP VALVES

When the valve is pressed against the disk it is then ground true.

I have charge of four 40,000,000-gallon pumps and grind over 1000 valves a month in this way. It takes a man two days to grind them.

A fair job can be done by securing the disk to the end of any shaft and holding the valve with the hand, it being mounted on a wooden block similar to the iron block.

This rig can usually be hooked onto an emery wheel by putting it between the safety collar and the nut and making a guide as shown, bolting it to the stand which carries the journals.

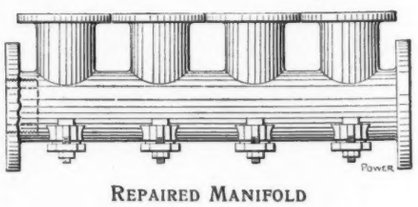
S. H. FARNSWORTH.

Chicago, Ill.

Repaired Economizer Manifold

A manifold of a fuel economizer cracked just around the fillet to the flange.

The manifold was removed and fastened in a lathe and the inside smoothed



REPAIRED MANIFOLD

up as far as the branch. It was then threaded, and a nipple screwed in place. The nipple can be painted with either red lead or smooth-on.

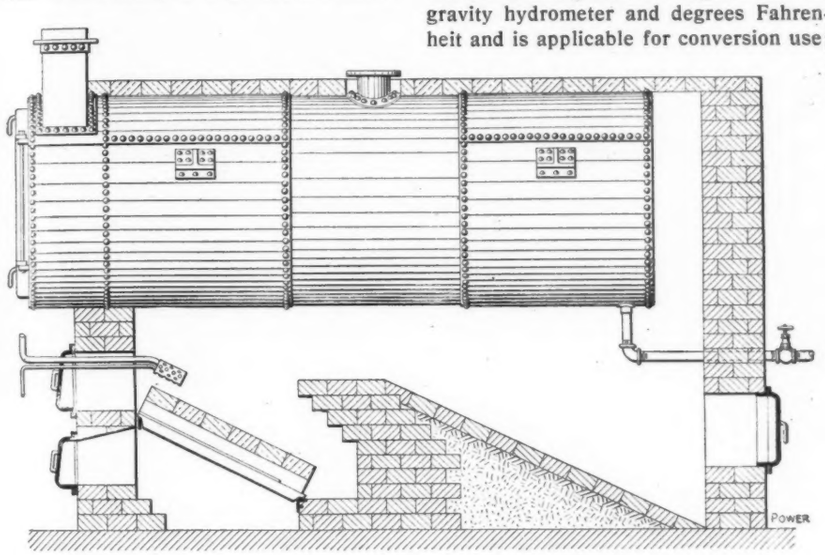
H. R. BLESSING.

Philadelphia, Penn.

Two Designs of Oil Burning Furnace

I am using oil and am getting good results. I burn from 36 to 39 gallons of oil per hour and develop from 155 to 175 horsepower.

The furnaces are also fitted for burning coal except that the grates are covered with asbestos mill board to within 18 inches of the back end. Bricks are placed end to end from the bridgewall to the front, in rows about 3 inches apart, and are then covered from back to front with bricks closely packed and covered with clay and sand. This forces the air from the back end of the grates through the 18-inch opening and causes it to travel between the asbestos covering and the heated brick and clay above before reaching the fire. I have no bridgewall and find this to be the best furnace I have tried.



DESIGN OF OIL-BURNING FURNACE

Thinking to get better results, but failing utterly, I dropped the back end of the grates, covered them as before, and built a bridgewall to within 16 inches from the boiler so as to force the products of combustion up toward the front of the boiler. I also allowed some air to come in at the bridgewall end of the grates through a 1-inch opening. The oil burner was turned downward so that the flame was about 5 inches from the bottom of the furnace.

This produced so hot a fire that the brickwork was melted and the heat was fierce at the furnace front. It took nearly twice the fuel to get the same work done as was obtained with the original furnace. The accompanying illustration shows how the furnace was arranged.

Can anyone tell me why the second furnace did not give satisfactory results?

P. H. WAYNE.

Newton, Kan.

Effect of Temperature Change on the Gravity of Crude Oil

The accompanying diagram shows the results of a test for variations in gravity of California crude oil by changing the temperature, heating the oil from 40 degrees to 140 degrees Fahrenheit and allowing it to cool; the readings were taken at the points designated during the process of both operations.

The curve drawn indicates the average relation existing between degrees Baumé, gravity hydrometer and degrees Fahrenheit and is applicable for conversion use; its plotting is based upon a mean center of gravity of the points located.

The oil selected for the test contained close to 4/10 per cent. of moisture and is regularly used in California for fuel purposes.

A. W. LYONS.

Oakland, Cal.

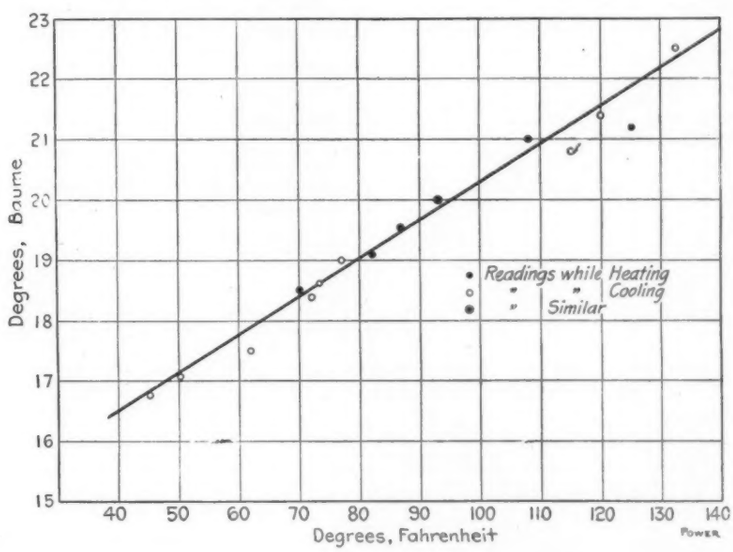
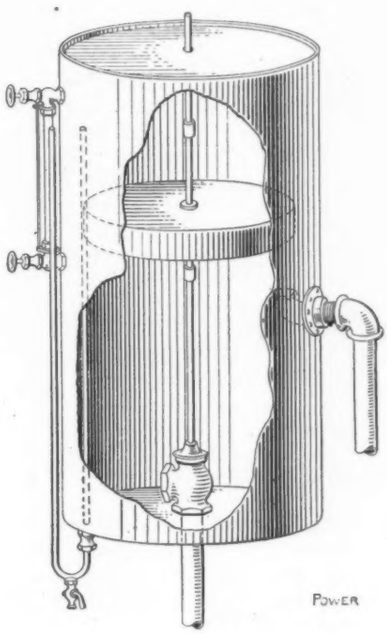


DIAGRAM SHOWING EFFECT OF TEMPERATURE CHANGES ON THE GRAVITY OF CRUDE OIL

Oil Extractor

The accompanying illustration shows an oil extractor which I have perfected. It can be made out of any kind of tank. I have a sump under my engine which catches all of the drain water. This water is then pumped into the tank by a small pump.

I use ½ gallon of oil daily and reclaim one-half of it. I think this is very good. The sketch is self-explanatory. The brass sliding drain pipe is of the same length on both sides of the U-bend, but the outlet end is closed.



OIL EXTRACTOR

W. I. CRAWFORD.

St. Louis, Mo.

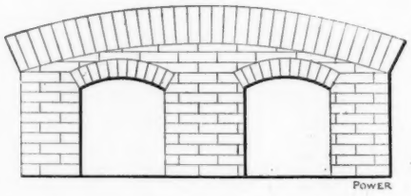
Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Furnace Arches

On page 441 of the September 19 issue, H. B. Jahnke writes of trouble with furnace-door linings.

In the case of the ordinary size furnaces, say up to 6 or 7 feet wide, he can have a firebrick arch built, with a rise of 5 or 6 inches in the center, and supported entirely on the side walls. Piers can then be built between the firedoors and between the firedoors and side walls, which have no supporting effect on the



DESIGN OF FURNACE ARCH

arch; these are easily and cheaply renewed when worn out. The illustration shows the idea.

I have such an arch under one of the boilers in the plant where I am employed which has worn out one entire furnace lining, and is well along with the second one.

A. G. KNIGHT.

Omaha, Neb.

In reply to H. B. Jahnke's letter in the September 19 issue regarding firebrick arch, I would say I have used the dutch-oven type of firebox shaped like a big arch and 6 feet square. Refuse, such as sawdust and planer shavings, fed through the top of the firebox by conveyers, are burned mostly and very good results are obtained. The arch will stay up when well made until the bricks melt away to almost nothing. I use the best firebrick I can get and pay freight for transporting it nearly 1500 miles.

I have a form made in the shape the arch is to be, say two bricks lengthwise and as near a half circle as practicable. Ordinary arch brick is used with edges, say, 2x2½ inches, and I build on over the form with very thin fireclay as a binder and use it sparingly; in fact, I just dip the bricks and avoid working in small pieces.

Wooden blocks or bricks are employed for supports under the form, and if the bricks do not come tight over the form, I lower the form enough to make them tight without using split bricks. A second arch is built over the first in the usual way. This holds the whole structure together and should the first or main arch get damaged from any cause, I can continue to run until there is time to repair it.

An arch like this made out of good firebrick does not bend and warp like iron lining, and will last a long time.

B. ZANADKE.

Libby, Mont.

Questions for Discussion

In reply to the questions asked by H. R. Rockwell in the September 12 issue, I wish to say that I do not believe a single empty red-hot boiler will explode.

If a red-hot boiler were connected to a battery under pressure, I believe that it would, if not protected by an automatic stop valve, undoubtedly explode, because when the water strikes the boiler shell the seams would rupture, thereby releasing the steam pressure. The pressure in the other boilers would be converted into steam faster than it could escape, thereby causing an explosion.

Cutting two or more boilers together at unequal pressures will not cause an explosion, provided care is taken in opening the valve. If the difference in pressure is great, say 50 pounds in one and 150 in another, a strain is put upon the boiler shell containing the least pressure, owing to the steam space being heated more rapidly than the part below the water line. I do not call this really dangerous, but it is undoubtedly bad practice.

If one boiler in a battery explodes it is liable to cause all to explode, unless they are provided with automatic valves. The reason is given in the first answer.

A condensing engine suddenly relieved of its load will not increase in speed when the throttle is closed, but will run for some time if a vacuum is maintained. The vacuum will gradually drop, as when steam ceases to enter the condenser it cannot maintain its usual vacuum.

C. E. ALDRICH.

Patterson, Cal.

Sand in Bearings

Some engineers advocate using Sapolio for cooling a hot box. It works very well sometimes, especially if the parts do not fit properly or there is lack of alinement, but I would not think of using it on a good machine as it will badly score the pin and brasses.

What took my breath was the editorial favoring putting sand in a bearing. I may be behind the times, but it makes me uneasy to see sand anywhere near the engine and I always feel like kicking a man when I see him set his oil can down on the floor or where it might pick up grit.

J. O. BENEFIEL.

Anderson, Ind.

Power Plant Betterment

I was very much interested in reading the article written by Mr. Bailey in the September 5 issue under the above heading, as well as others under the same heading.

I agree with Mr. Bailey when he says that very few of the engineers in plants of 250 horsepower or under have indicators. I have seen several plants where the engineer did not know what an indicator was, and many places where the engine had never been tapped for an indicator. One plant has been run for 40 years. I have heard some old engineers say that they did not need an indicator to set a valve for they could set it just as well, or better, without it. I also know of an engineer who can neither read nor write. The people who employ such men deserve to pay well for their power.

In some of these poorly operated plants an expert cannot better the conditions because the management will not listen to him. It seems to think it is cheaper to run with a high operating cost than to spend a little money for repairs or for a new machine in order to lower them. Usually they have no way of knowing which would be the cheaper and they just use their own judgment. In such a place there is no chance for betterment.

E. V. CHAPMAN.

Decatur, Ill.

Corrosion of Hot Water Heater

In the October 3 issue of POWER, page 524, is an inquiry from Asa P. Hyde, of Binghamton, N. Y., who is having considerable trouble with corrosion with a hot-water heater.

Mr. Hyde says that the water in the heater which is causing the trouble comes from the city supply. We would also judge from Mr. Hyde's letter that at no time does the water come in contact with steam or oil, but is heated entirely by means of the brass coil to which he refers.

We have on hand an analysis of water from Binghamton, N. Y., marked "River Water," which is given herewith:

ANALYSIS OF RIVER WATER

Incrusting Solids	Per Ct.	Nonincrusting Solids	Per Ct.
Calcium carbonate	2.35	Sodium sulphate.	none
Calcium sulphate	0.20	Sodium chloride	0.40
Calcium chloride	none	Sodium carbonate	none
Calcium nitrate	none	Sodium nitrate	none
Magnesium carbonate	none	Total	0.40
Magnesium sulphate	1.02		
Magnesium chloride	0.14	Volatile	
Iron and aluminum sulphates.	none	Free carbon dioxide	0.29
Iron and alumina.	0.06	Half-bound carbon dioxide	1.03
Silica	0.20	Hydrogen sulphide	none
Suspended matter	0.70	Total	1.32
Total	4.67		
		Hardness	3.50
Pounds in 1000 gallons	0.67	Alkalinity	2.33
Free sulphuric acid	none	Acidity	none

In this connection we call attention to the presence of magnesium chloride and to the fact that this river water is fairly soft water, although the magnesium sulphate in it would probably give rise to scale.

The difficulty Mr. Hyde speaks of would lead one to believe that the trouble is due entirely to corrosion. This, if caused by a water of the nature previously described, would undoubtedly be due either to the presence of free carbon dioxide in the water in sufficient amounts to cause corrosion or to the presence of magnesium chloride, which is accepted by all chemists as being one of the most objectionable salts which could be present in a water used for such purposes as Mr. Hyde describes.

It is a very objectionable mineral when present in boiler waters, being very corrosive and quickly pitting and grooving boilers.

Mr. Hyde's description of the effect of corrosive water on cast iron, and also the fact that he is troubled by red, rusty water, which is hard to clear, is positive evidence of direct corrosion. The fact that other people in the town, plumbers, etc., are having trouble with water fronts and range boilers would go to confirm the opinion that it could be attributed to a corrosive water, and the best possible way for him to arrive at some method of stopping it would be to have an actual sample of the water analyzed and a recommendation made based on the exact analysis as to what chemicals should be used to counteract the effect of any corrosive substances present.

The fact that the water in the same locality has corrosive salts present would certainly confirm the above opinion. It is a problem which has been met and taken care of many times.

THE KENNICOTT COMPANY,
BY F. S. DUNHAM.

Chicago Heights, Ill.

As to the article on corrosion of hot-water heater, by Asa P. Hyde, in the October 3 issue, I believe his trouble is due to the water he is using. His boiler compound or his fear of electrolytic action occurring need not bother him, but he should look after the water.

Chemically laden water will have disastrous effects on iron, tending to set up a corrosive action which, in a very short time, makes it necessary to renew parts.

The ingredients in the water which tend to be so destructive when coming into the heater and are deposited on the metal are such that renewal of the corroded parts is finally necessary.

I recommend that Mr. Hyde have the water carefully analyzed and then put in the new parts made up of a metal which will withstand this action; of course, this new metal must be such that no possible electrolytic action can set up. The combination of metals will always tend to set up an action which is, and has often times proved, to be as destructive as any kind of local conditions.

NATHAN OWITZ.

New York City.

Asa P. Hyde, on page 524 of the October 3 issue, asks regarding the corrosion of hot-water heaters.

I have had more or less difficulty along the same line, not only with heaters, but with boilers. In some cases the water was so full of free carbonic-acid gas that trouble was experienced in keeping things tight; in others, the character of the water was such that the scale produced acted on both the boiler shell and the tubes.

The solution is to properly purify the water. In some isolated cases too pure water has brought about the same results. The remedy is obvious: add some alkali to make the water slightly impure. It is advisable in some instances to frequently change the water in the boilers so as to prevent the possibility of its becoming absolutely a distilled water, which might happen in a closed heating system.

HENRY D. JACKSON.

Boston, Mass.

Adjusting the Mercury Column

In the issue of October 3, Luke J. B. Marier describes how he put a screw adjustment under the cup of his mercury vacuum gage to keep the level of the mercury in the cup constantly even with the bottom of the scale. He may have been perfectly right in doing this, but I would advise anybody desiring to follow his example to first measure the scale and see if it really is a scale of inches or if each pound pressure on the gage measures 2.04 inches on the scale. If not, then the maker of the gage has probably made an allowance for the level of the mercury in the cup going down as that in the tube goes up.

If, as in Mr. Marier's case, the level of the mercury in the cup falls 1 inch while that in the tube goes up 27 inches, thus indicating a 28-inch vacuum, and if the maker has made the proper allowance, each inch of vacuum on the gage will be found to measure $\frac{27}{28}$ of an inch. In this case it is not only unnecessary, but wrong, to change the level of the mercury in the cup, and the only adjustment needed is to see that the mercury in the tube goes to "0" when the vacuum or the pressure is zero.

A. E. MUELLER.

Mayville, Wis.

I was interested in Mr. Marier's account, in the October 3 issue, page 526, of his experience with mercury columns, as it reminded me of two points that often escape the notice of the practical engineer. One is the adjustment of the scale as noted in his article, to give the true hight of the mercury column; the other, a point that may have as great significance, is the presence of water on top of the mercury.

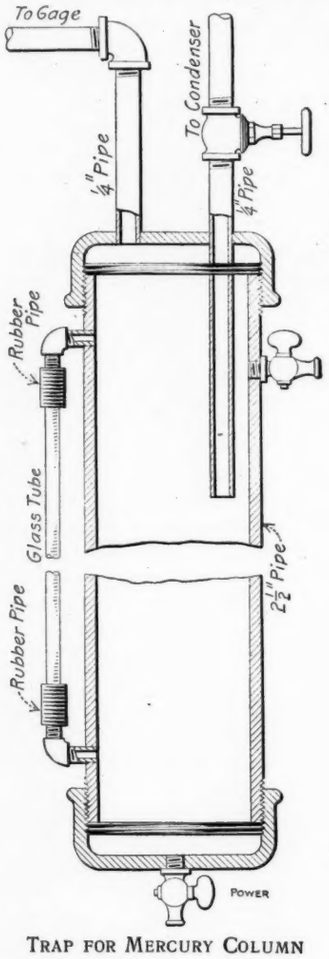
Where the gage is connected direct to the condenser, with no intervening trap, water often collects in the tube. Many an engineer does not realize that this may introduce a serious error. Thirteen and a half inches of water is equal to an inch of mercury in the pressure it exerts, so the pressure of this much water will cause the reading on the mercury column to be an inch low.

Of course this error may be corrected by a calculation, but the most satisfactory way is to keep the water out of the mercury column. This may be done by putting a trap in the line leading from the condenser to the gage. A trap may be bought or it may be made.

The accompanying illustration shows the design of a trap which can be made easily by a pipe fitter. Take a piece of 2½-inch pipe about 12 inches long and drill and tap it near the ends for a petcock and two ⅛-inch nipples. The nipples should be as short as possible, and should have elbows with short nip-

ples screwed on so that the two nipples point at each other. Cut a piece of glass tubing to the proper length and fasten it to the nipples with short pieces of rubber tubing, which should be wired securely to prevent leakage. This arrangement makes a simple water glass.

Screw a cap with a petcock in the middle to the lower end of the 2½-inch pipe, and another cap with two pieces of ¼-inch pipe screwed into it, one projecting downward about 4 inches. To the upper end, connect the projecting pipe to a valve in the line from the condenser, and run the other to the mercury column.



TRAP FOR MERCURY COLUMN

When water collects in the pipe from the condenser and fills the trap so that it shows on the water glass, the valve in the condenser line may be closed and the two petcocks opened, allowing the water to run out. This operation takes only a few minutes and insures a dry mercury column.

If no water shows on the mercury gage, have all connections tight, so that there is no leakage of air, and have the scale measure from the surface of the mercury in the well. One may then be sure that the gage will give a correct reading.

J. F. MOWAT.

Joliet, Ill.

Taper Piston Fit

In the October 17 number, page 596, F. W. Brady describes a method of putting the piston on the rod with a straight "easy-sliding fit—just tight enough not to wabble." I would consider such a job unsafe in an engine of large size.

Mr. Brady especially objects to the practice in marine work where the piston is forced on tight and the rod end is sometimes riveted over. A marine engine must, above everything else, be dependable. It is sometimes put to very severe service, such as being reversed and going full speed astern as soon as possible after stopping.

When running in a heavy sea the wheel is often partly out of the water and the engine races violently.

The stopping of an engine, even for a few minutes in heavy weather, may cause the loss of the vessel and her crew. I think that the builders of these engines are justified in putting the pistons on as though the job was to stay finished forever.

JAMES H. CAMPBELL.

Bloomington, Ill.

Engine Runs with Steam Valves Closed

Referring to O. Lantz's letter in the issue of September 5, the cause of his engine running with the admission valves closed is probably leaking steam valves and tight exhaust valves. The steam which leaks into the cylinder in front of the piston escapes through the open exhaust valve, while that behind the piston is prevented from escaping by the closed exhaust valve on that side.

Newly fitted Corliss valves are not always tight; in fact, I believe, as usually fitted, they are more likely to leak than not.

I make it a practice to take these valves out frequently and if they are not wearing to suit me I drawfile the high places, especially the head or part that extends beyond the ports. This has a tendency to cause the high parts to wear faster and bring the low parts into contact with the seat.

It has always seemed to me that there was a tendency for the solid ends of the valves to wear less than the part covering the front, owing to the greater surface which the solid parts have.

With a double-eccentric engine in which the steam valves are set with little or no lap, when the steam wristplate is unlatched and the exhaust wristplate is latched, live steam might pass into both ends of the cylinder and cause the engine to run as previously described.

J. O. BENEFIEL.

Anderson, Ind.

Engine Knocks

In the October 3 issue, page 524, W. A. Mills requests information as to a knock in the low-pressure cylinder of his engine.

If he will remove the low-pressure cylinder head and try the nut on the piston rod, with a large wrench, he will no doubt find it loose. A loose piston will make a knock hard to locate, though it is often attributed to a loose crank pin.

After tightening the piston-rod nut, it is well to mark the nut and rod so that future movement can be detected. If the nut is found tight, then examine the crank and crosshead brasses to see if they are cracked; at the same time see if the crank pin is loose; an inspection should also be made of the crosshead pin.

The pins may have become smaller through wear and they should be calipered to see if they are true. If badly worn it may be necessary to plane off more clearance where the brasses come together, so that the brasses can be keyed to the right place.

Too much compression will also cause a bump in the cylinders and should be remedied by an adjustment of the valve rods. Indicator diagrams should be taken to see if the trouble lies in this direction.

The clearance space in both cylinders should be looked after to see if the piston touches the heads at the end of the stroke.

A. RAUCH.

Swissvale, Penn.

Flywheel Explosion at West Berlin

In the October 3 issue, G. H. McKelway takes exception to certain statements in my letter concerning the flywheel wreck at West Berlin, and practically accuses me of carelessness in letting a circuit-breaker get into such condition that it would not open.

I want to ask Mr. McKelway if he had worked day and night for three or four months to get his plant into as good condition as possible, would he sit up until 1 a.m. to pull a circuit-breaker to pieces when it had never before failed to his knowledge?

After the flywheel explosion the plant was closed down for a week and electrical energy was supplied by another company having its terminus in the same town within a few feet of the tracks supplied by my plant. These lines carried 625 volts while my station carried but 575 at peak. When I started up I had not been informed of this; therefore I cut in with 575 volts as usual at 9 o'clock Sunday morning. At 9:30 our cars on both lines got to the end of their

respective lines. I was standing near to the throttle watching to see how things were going, and the night engineer, who was about half way between the throttle and the switchboard, was also watching for whatever might develop.

The instant the car carried by my plant reached the end of the line, as shown by the ammeter, the generator shot fire and the engine began to speed up. The night engineer jumped for the circuit-breaker and I closed the throttle. This incident led me to think of my explanation of the explosion of the other unit. Thirty seconds had not elapsed from the time that load went off and the engine started to speed up before it was making double its normal speed (which was 88 revolutions per minute), and I will take my oath that the steam valves did not open for two minutes after the throttle was closed, the circuit-breaker opened and the main switches pulled.

I got started up again after notifying the superintendent of motive power of my trouble and was informed that it would be necessary to carry higher voltage. Twice that afternoon I saw the load go to a point where the circuit-breaker ought to have opened. I had never seen it fail before so I reset the trip for 100 amperes less but did not get enough load to open it the rest of my run.

I notified the night engineer when he came on at 6 o'clock and told him to watch it, which he did. The next day it rained and the air cooled down about 40 degrees. The first thing I had to do after getting into the station was to put that breaker back into place, and I had to put it back several times that day and the next, and have not known it to stick since.

Now I would ask Mr. McKelway if there was carelessness or neglect, and what he would have done had he been in my place?

W. E. CHANDLER.

Northbridge, Mass.

Centrifugal Pump Capacity and Speed

T. W. Holloway, in his article "Centrifugal Pump Capacity and Speed," in POWER for October 3, page 508, states that theoretically the rim velocity of the pump runner should be equal to the velocity that a body would have after having fallen through a distance equal to the total head pumped against. This statement is not borne out by a mathematical analysis as will be shown.

A pump runner forces water against a head by virtue of the centrifugal force it imparts to the water passing through it. Now the centrifugal force acting on unit weights at unit radius and at a velocity V is

$$F = \frac{V^2}{g}$$

In the case under consideration F is proportional to and equal to the head h. Therefore,

$$h = \frac{V^2}{g}$$

The head pumped against or hight of fall in terms of g and V is

$$h = \frac{V^2}{2g}$$

Now it is evident that h in the first equation is of twice the value of h in the second equation, since V and g have the same respective values in each case; in other words, a perfect centrifugal pump will raise the water to a hight twice that due to the velocity of the circumference of the runner. As an example, suppose the rim speed of the runner to be 46.8 feet per second; a weight would fall freely through 34 feet to acquire this velocity and the total lift of this perfect pump would be 68 feet.

Mr. Holloway's equation

$$V = 480 \sqrt{h}$$

where V is velocity in feet per minute, is very close to the equation used in designing ordinary centrifugal pumps, includes quite an efficiency factor and therefore is some distance from the theoretical point.

N. C. HURST.

Aspinwall, Penn.

Engineers' Wages

In the editorial published in the October 10 issue under the above title, there is much that is good. It is true that engineers are working for laborers' wages; in fact, for much less, if the weekly wages are reckoned by the number of hours put in on the job.

In Massachusetts there is some protection, as the license law prevents unscrupulous employers from hiring inefficient help, who in reality are only "stoppers and starters."

The editorial speaks of the charges of graft hurled at the engineer, and expresses the belief that not more than 5 per cent. would accept graft. I believe that 5 per cent. is high and that the majority of engineers do suffer by the acts of the few.

This charge of graft does not apply to the engineer alone, but will be found in any profession where the party is allowed to purchase supplies. If there is one thing more than another which makes engineers angry, it is to have an advertiser continually harping on the subject of "graft." Surely the crusade of "graft" must have reached all the "grafters" by this time, and if the number is less than 5 per cent., there ought to be enough business among the other 95 per cent. of honest engineers to appeal to them for their custom. This is not an appeal from the "grafters," but a protest from the others. The advertisements of POWER are read by managers and superintendents as well as by the engineer, and it is giving them the impression that they can hardly trust any engineer in their employ.

It looks to me more like coercion than anything else. That if an engineer is not buying certain kinds of supplies he is a grafter, because none of the other supply houses are not crying down graft. I, for one, do not care to see this kind of advertising, and am sure that it makes no appeal to the engineer. I hope this letter will be published, for it is the sentiment of not only myself but of others who have discussed the matter with me.

WILLIAM J. MASSEY.

Cambridge, Mass.

Scrub Engineers

Replying to the question asked by J. W. Dickson in his letter on page 525 of the October 3 number, I would say that a man is an engineer in Massachusetts when he qualifies for his license at the State house. When he gets that license no night watchman or carpenter can keep him out of a job by running it.

Such conditions as Mr. Dickson writes of prevail in a number of places, but not in any State which has an engineers' license law.

The license has the effect of raising the standard of the engineer and the service and will protect a man who has spent a lifetime at the business.

The only remedy for the conditions which Mr. Dickson describes is a license law.

WILLIAM F. O'REGAN.

Brighton, Mass.

Installing Oil Tanks

Referring to the many answers to my inquiry regarding the unloading of fuel oil, which was published in the August 15 number, I beg to advise that the Standard Oil Company has informed me that no pressure whatever will be allowed on my tanks, therefore some other means must be used. Who can suggest an acceptable method?

W. W. WARNER.

Kent, O.

Improved Stop Valve

An excellent idea is shown in the valve illustrated and described by Yaekichi Sekiguchi on page 523 of the October 3 issue, and is very similar to a valve gotten out several years ago by a well known valve manufacturer whose valve has merit beyond that mentioned by Mr. Sekiguchi, inasmuch as it is a truly "spring-seat" valve accompanied by all the self-compensating features of such a mechanism.

FRANKLIN M. PATTERSON.

Jersey City, N. J.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Flow of Air through an Orifice

Give formulas for the flow of air, through an orifice in a receiver, into the atmosphere, under constant conditions of pressure and temperature. Also, would the coefficients of contraction used in these formulas for various-shaped openings apply equally as well to steam and water?

C. E. S.

Numerous empirical formulas are to be found for the flow of air through an orifice; based largely upon the findings of different investigators.

The theoretical flow of air through a circular orifice, as given in "Kent," page 589, and considering the air to be at 60 degrees initial temperature, is

$$W = 0.000491\, d^2 P_1 \sqrt{\left(\frac{P_2}{P_1}\right)^{1.425} - \left(\frac{P_2}{P_1}\right)^{1.712}}$$

where,

W = Pounds discharged per second;
d = Diameter of orifice in inches;
P_1 = Initial pressure, or that inside the receiver, in pounds per square foot;
P_2 = External pressure in pounds per square foot.

In practice this must be multiplied by a coefficient of discharge which varies slightly with the size of opening and the head. However, for all practical purposes this coefficient may be taken as 0.6.

The same coefficients for nozzles and different-shaped openings would not be used for air, steam and water.

Condensation in Bare Steam Pipe

How may the quantity of steam condensed in uncovered steam piping of various sizes be calculated?

F. W. O.

Experiments by George M. Brill, reported in the *Proceedings* of the American Society of Mechanical Engineers, volume XVI, page 827, showed a condensation of 0.846 pound of steam per square foot of bare pipe per hour with a pressure of from 109 to 117 pounds gage and a temperature of the air of from 58 to 81 degrees. This is 2.706 B.t.u. per square foot per hour per degree of average difference of temperature.

Experiments reported by H. G. Stott in POWER, of December, 1902, give 2.708 B.t.u. for the same quantity.

The quantity may be influenced considerably by the flow of air over the surface. If the conditions are such that the heated air can get away readily, allowing cooler air access to the pipe, the condensation will be more rapid than if the circulation is restricted.

The total heat in a pound of steam at 165 pounds absolute (about 150 pounds gage) is 1195 B.t.u. Its temperature is 366 degrees. If the average temperature of the room is 66 degrees, the average difference will be 300 degrees. Assuming that the transmission per degree of difference will be 2.7 B.t.u. per square foot per hour per degree difference of temperature, each square foot of surface will radiate

$$2.7 \times 300 = 810 \text{ } B.t.u.$$

per hour. The steam will be condensed to water at 366 degrees, each pound of which will contain 338 B.t.u. Each pound of steam in condensing to such water will give up

$$1195 - 338 = 857 \text{ } B.t.u.$$

and each square foot of surface will condense

$$\frac{810}{857} = 0.94 \text{ } pound$$

per hour.

The condensation for other pressures and temperatures may be computed by taking the corresponding values from the steam tables.

Gas Engine Exhaust Heating

Water is injected into the exhaust pipe of a gas engine to cool it and muffle the sound. This water instantly flashes into steam. Is there any practical way in which this steam may be used for heating purposes?

C. J. B.

It is not practicable to use steam made in the exhaust pipe of a gas engine for heating purposes on account of the corrosion which will take place in the piping from the condensation of the gases.

The heat may be utilized by passing the gases through a heater similar to the closed heaters used with steam engines.

Horsepower of Belting

What horsepower will be transmitted by a double leather belt 39 inches wide running over a flywheel 16 feet in diameter?

F. M. P.

For a double belt 45 square feet of surface passing over a pulley in one minute will transmit one horsepower.

The belt is 3.25 feet wide, and the pulley is 50.26 feet in circumference. Therefore, the belt will transmit

$$\frac{3.25 \times 50.25}{45} = 3.63 \text{ } horsepower$$

for each revolution the pulley makes per minute.

This is for a belt working under fair conditions of tension and speed. By excessive tension it may be made to do a great deal more for a short time.

Collapsing Pressure of Corrugated Flue

How is the collapsing pressure of a corrugated furnace flue calculated?

B. W. E.

Multiply the square of the thickness of the flue in thirty-seconds of an inch by 1200 and divide the product by the greatest diameter in inches multiplied by the square root of the length of the flue in inches.

Shims in Connecting Rod Ends

What are shims and for what purpose are they used?

C. R. E.

Shims are thin strips, usually of metal, used to fix or to limit the distance between parts of machines. In connecting rods they are placed between the brasses and the rod ends to preserve the correct rod length and to aid in taking up the wear of the brasses.

Effective Pressure of a Screw

How can I determine the force exerted by a screw moved by a lever of a given length and a known pressure at the end of the lever?

G. P. P.

The effective pressure exerted by a screw is modified to an unknown degree by friction and is undeterminable by calculation. In some cases the reduction due to friction has been estimated at 75 per cent. of the power applied, and in others at 50 per cent. It is a case where the actual force exerted will have to be estimated.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 32,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

PAGE

An Office Building Central Station..... 726
Notes on Crude Oil Fuel..... 730
Pioneer Power Plant of California..... 731
A Commercial Water Power Problem.... 732
Largest Corliss Engine on the Pacific Coast 734
Novel Features of Mine Power System... 735
Flywheel Explosion, Farmington, Utah.. 737
Half a Billion Tons of Coal..... 738
Rewinding a Direct Current Generator.. 739
Mr. Ropeter's Comment on Mr. Edge's Wiring 741
Failure of a Generator Due to a Swinging Open Circuit 741
Flywheel Wreck at Hagerty Shoe Factory 742
Effects of Sulphur in Fuel Oil or Gas... 743
The Grine Crude Oil Gas Producer..... 743
Properties of Heavy Oils..... 744
Practical Letters:
Wire in Compressor Piston....Substitute Trap Bucket....Union for Tank Cars....Temporary Pump Repair....Handle for Furnace Door ....Unequal Port Opening....Purchasing Hair Felt .... Truing Up Rubber Pump Valves....New Way of Packing a Stuffing Box....Repaired Economizer Manifold .... Effect of Temperature Change on the Gravity of Crude Oil....Oil Extractor...745-747
Discussion Letters:
Furnace Arches .... Questions for Discussion....Sand in Bearings.... Power Plant Betterment....Corrosion of Hot Water Heater....Adjusting the Mercury Column .... Taper Piston Fit....Engine Runs with Steam Valves Closed....Engine Knocks .... Flywheel Explosion at West Berlin .... Centrifugal Pump Capacity and Speed....Engineers' Wages .... Scrub Engineers .... Installing Oil Tanks....Improved Stop Valve 748-751
Editorials 753-754
Precooling Plant of the Santa Fé Railway 755
A Timely Rescue..... 759

POWER

The Panama Pacific Exposition

With the plans for the Panama Pacific Exposition now well under way, it seems opportune to call attention to the necessity for having the engineering features form a prominent part of the program. This is especially fitting: first, because the exposition is to commemorate the building and completion of the Panama canal, one of the greatest engineering feats in history, and, second, because through its application to engineering it will be able to exert a potent and lasting influence.

Going back to the records of the Centennial Exposition at Philadelphia in 1876, we find therein not only a large amount of space devoted to the description of engineering apparatus, but also the reports of very complete tests upon much of the apparatus. For the purpose of making these tests a board of prominent engineers was appointed and the importance of their work is evinced by the fact that it is still the standard of procedure, and the basis of the official unit of boiler horsepower, which was defined as equivalent to the evaporation of thirty pounds of water into dry steam at seventy pounds pressure from feed water at one hundred degrees Fahrenheit.

During the intervening period between 1876 and the present, numerous expositions have been held, but, with the possible exceptions of the Chicago and the St. Louis Expositions, they created only a passing interest and left no permanent effect. This was largely due to the fact that they were little more than show places in which the exhibitors advertised their wares.

With the rapid development in prime movers during the past few years and the revision of certain engineering equivalents as a result of more refined methods of scientific research, many of the engineering standards are now in a chaotic condition. Therefore, the time is ripe for some authoritative commission to readjust these standards to meet the needs of modern practice. A prominent engineer, Charles C. Moore, of San Francisco, has been chosen as president of the Panama Pacific Exposition, and with this start it is hoped that the work will fulfil the expectations of the engineering profession and make its influence in this field lasting.

The "Block" Central Station

In many cities, especially on the Pacific coast, there exist what for lack of a better term may be called "block" central stations. One such, located in Los Angeles, is illustrated in this issue. The "block" station may be described as a station which serves anywhere from two to a dozen or more buildings in its immediate neighborhood as, for instance, all of the buildings on a city block.

Such a station possesses possibilities which the usual type of central station does not. From the "block" station not only electrical energy may be distributed but steam for heating and other purposes, water under pressure for elevator work, and even vacuum-cleaning service and brine for cooling purposes may also be supplied economically. The large central station is unable to supply anything but electricity to any of its customers except those in its immediate vicinity.

At the present time, in practically all of the industries, every effort is made to utilize the byproducts with profit. The light, heat and power industry should be no exception to the rule. The chief byproduct in power generation is exhaust steam. In a great many localities the most profitable use to which exhaust steam may be put is to pass it through the heating coils. Hence, the "block" station seems more logical than the exceedingly large central station which is the common type at present.

In the municipality of New York the "block" station does not thrive. If an individual, firm or corporation wishes to lay conduits or pipes under the streets of New York City for the purpose of distributing for profit to outside parties electricity, gas, steam or the like, a franchise from the city must first be obtained, and a franchise is not always easily obtainable. This may explain why "block" stations are not numerous, but it does not explain why they scarcely exist at all. A franchise is not required to pass conduits and pipes from one building into those which stand alongside of it, and surely there must be many groups of two or more adjoining buildings in the city which could be served advantageously by a single plant contained in one of them.

We all know that if the "block" station were to become numerous, central-station business would suffer. What this

fact has to do with the other fact, to wit, that "block" stations are not numerous in New York City, we do not know. We only know the facts themselves. And we also know that the city itself found it most difficult in attempting to make one of its plants into a "block" station.

New York City's Hall of Records contains a well designed power plant of such size as to be capable of lighting and warming the City Hall and the city court house which are less than one short block away. Someone in the borough president's office made the suggestion that the Hall of Records' plant be made to serve these buildings with heat and light and thereby do away with central-station service in them. The suggestion being attractive, word was given to go ahead.

In order to carry out the suggested scheme it was necessary to extend steam pipes and electric conduits under Chambers street. It seems, however, that the carrying out of this plan required the sanction of another city department and when the latter found out what was in the wind, difficulties arose. We are informed that practically no objection was made to laying the steam pipes (which was done) but the laying of electrical conduits was successfully held up. As a result the electrical load upon the Hall of Records' plant is not great enough at present to furnish exhaust steam for all the buildings and consequently this has to be supplemented with live steam.

Another incident closely connected with the foregoing relates to supplying light, heat and power to the new municipal building, located across the street from the Hall of Records. Owing to the subway passing through the basement of the municipal building, little room is afforded for a power plant. However, the plans call for a heating plant in conjunction with central-station lighting and power service. It is understood that, here again, the suggestion was made to place some additional units in the Hall of Records' plant (for which there is adequate space) and supply the new building from this source. This would have made an ideal arrangement, and we ask again, Why was it not adopted?

The New York License Board

Whatever may be the prevailing view regarding the failure of the new charter for New York City to pass the legislature there can be only regret upon the part of those who have to do with the examination and licensing of engineers that the proposed change in that respect did not materialize. At present this is a function of the police department. Under the provisions of the new charter the licenses would have been issued by the Commissioner of Licenses upon the recommendation of a board composed of one member suggested by the National Association of Stationary Engineers, one by the International Union of Steam Engineers and one other. It is certain that a board constituted in this way would be able to pass with the intelligent appreciation which comes of personal service in the same line upon the capacity of candidates, and that any attempt to grant licenses for any other cause than merit or to withhold them for any other cause than incapacity would meet with prompt resentment by the qualifying associations. It is to be hoped that the matter will not be dropped, but that some way may be found even yet to bring about this desirable arrangement.

Feed Water Regulators

What is the use of a feed-water regulator?

Ninety-nine men out of a hundred would say: "To keep the water level constant."

Well, what is the use of keeping the water level constant? So long as the water is not allowed to get so low as to endanger the heating surfaces nor so high as to be carried over with the steam, what difference does it make if the water level does vary an inch or two?

The answer is that a perfectly constant water level is supposed to indicate that the feed water is entering the boiler at exactly the same rate with which the steam is being drawn off. In other words, that the rate of feeding is graduated or variable. In average practice, however, an automatic feed-water regulator is either wide open or tight shut and there is no intermediate position. It keeps the water level apparently constant by varying the relative lengths of the open and shut periods. It is just this feature which might reasonably be objected to on two distinct grounds: first, the heating of the feed water, and, second, the metering of the feed water. Suppose a one-hundred-horsepower boiler to have a water surface of ninety square feet and to be evaporating at its rated capacity of thirty thousand pounds per hour. If the boiler-feeding capacity be sixty thousand pounds per hour, it is evident that the automatic regulator will be open just half the time, and if the regulator be adjusted to open and shut with a variation of one-quarter inch in the water level, the periods of feeding and no-feeding will each be four minutes long. Similarly, if the regulator permit a water-level variation of one-half inch, these two periods will each be lengthened to eight minutes.

During the period of no-flow the water in the feed-water heater will become very hot, but during the period of flow the water will not have time to take up sufficient heat from the heater and will enter the boiler at too low a temperature. The harmful effects of such variations in feed-water temperature are noticeable both in the fuel consumption and in the wear and tear of both boiler and heater. The extent of injury generally increases with the temperature range and also with the frequency of temperature change.

There is at present a very pronounced movement in favor of accurately measuring the amount of feed water to boilers, and this, of course means that the metering devices must be capable of handling very hot water. Numerous satisfactory methods for measuring cold water have been upon the market for many years, but the number of devices that are permanently accurate with hot water is quite limited and these give the best results only when the rate of flow is reasonably uniform. Constantly recurring fluctuations in the rate of flow ranging from zero up to full capacity are almost fatal to accurate hot-water measurements.

Fortunately, however, there are at least three different methods of reducing the extent and frequency of fluctuations resulting from an automatic regulator and in most cases all three methods may be used at the same time.

The first method consists in placing a small bypass pipe containing a valve around the regulator, thus allowing some water to be fed during the period when the regulator is closed. So long as this bypass valve is not opened too wide for the minimum rate of steaming there will be no danger of flooding the boiler. Instead of the bypass pipe, a notch or hole can be made through the valve disk or seat of the regulator.

The second method consists in having a throttling valve in the main feed pipe either before or after the automatic regulator. This valve can be throttled to such an extent that the maximum flow with the regulator open will be only slightly in excess of the maximum rate of steaming and consequently the duration "regulator-open" period will be increased. This narrowing of the limits of minimum and maximum velocities also reduces the frequency of regulator action.

The third method consists in adjusting the float of the automatic regulator so as to make the device less sensitive, thus permitting a somewhat greater variation in the water level. This reduces the frequency of regulator action.

These three suggestions may involve an occasional sounding of the high- or low-water alarm, but it will produce a flow approximately proportionate to the rate of steaming with the advantages already enumerated.

More or less successful efforts have been made to produce an automatic regulator that will permit a variable rate of flow and to adjust this rate to approximate a rate of steaming. Such a device might have to sacrifice slightly in the maintenance of an exact water level, but this in itself is not necessarily a defect.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

Precooling Plant of the Santa Fe Railway

By L. R. W. Allison

Precooling

Precooling is a distinct departure in refrigerating work. It is often erroneously confused with the term cold storage, but, while necessarily involving a central refrigerating plant, it relates essentially to transportation, inferring a "time-limit" process. The problem of transporting perishable products to a terminal market many hundred miles distant without losses has long seriously confronted the railroads of the world, and vast sums have been expended in experimental work in an effort to discover an adequate method for the adaption of mechanical refrigeration to railway conditions.

The placing of such products in cold-storage rooms to chill to the desired temperature has proved unsatisfactory for many reasons. This demands excessive handling, the unloading and reloading of trains and the necessary equipment required therefor; also there must be considered the great expense thus involved. The time consumed in these labors, with the addition of from 48 to 60 hours for cooling treatment, as found under usual conditions, places an almost indefinite period of time upon shipments. Again, the ultimate market becomes an issue, the purchaser is left in doubt as to the actual length of cold-storage treatment, and the age of the product. The abuse of cold storage in this instance, as in many others, is evident; instead of being used legitimately for preparing for shipment, with reasonable time restriction, it is utilized for holding the product for the most valuable market.

Precooling accomplishes the desired result in a much more efficient manner, rendering an accordant temperature in from four to five hours, without any handling of the product. It is the immediate reduction of the temperature within the loaded refrigerator car itself, under a scientific treatment of cold-air circulation. Necessarily, this is attained by the use of a refrigerating plant, supplemented by a special balanced-air system, equalizing the differential pressures so established within the car. Considering the fact that refrigerator cars as constructed are by no means air tight; that to effect any change in such rolling stock, even to a slight degree, would represent an enormous expenditure, and of the positive "short-time" allowance for treatment, it would seem that the problem presented is of more than ordinary interest. Owing to the great limitations exacted, the really adequate precooling station is largely in the minority.

Santa Fé Plant

To minimize the excessive damage occurring annually in the transportation of fruits from southern California, the Atchison, Topeka & Santa Fé Railway Company has erected at San Bernardino, Cal., a combined ice-manufacturing and pre-cooling plant which has attracted the attention of the entire railroad and produce world. It stands as an example of the highest type of development of current-day precooling work, and is the most efficient station of its kind in existence. The Gay precooling system is employed, having been installed under the direct supervision of the designer C. M. Gay, of Los Angeles.

Located in the center of the citrus-fruit district, the plant has been in continuous service since its erection, early in 1910. Pick-up trains are operating throughout the entire San Bernardino valley, are taken to the precooling station as fast as loaded, and, after a delay of about four hours, proceed to their Eastern destinations. Only occasional subsequent icing, filling the car bunkers, is needed *en route*.

General Plan

The general arrangement of the plant is shown in Fig. 2. The main building, comprising the power plant, tank room, day storage and winter storage, is 511 feet 6 inches long by 132 feet wide. Connecting to the winter storage, the precooler coil chamber and icing dock extend for a distance of 737 feet 6 inches, the icing dock proper being 693 feet long. This gives a full length of 1249 feet for the plant, or approximately one-fourth of a mile.

The structure is entirely of reinforced concrete, with interior partitions and tunnels of the same material. The building may be considered as divided into two portions, one devoted to ice manufacture, the other to precooling. A reinforced-concrete reservoir has been built, partially underground, 30 feet away from the power-house end. It is 80 feet square by 10 feet deep and is used in connection with an ammonia-condensing system of the two-coil double-pipe type, which is placed over the front section of the basin coincident with the plant. Adjoining this a pump house has been erected for the ammonia system, consisting of two circulating pumps, one steam and the other electrically driven. There is a transformer station on a line with the pump house, and a crude oil tank, 20x30x10 feet, has been constructed similar to the water reservoir and parallel to the boiler room.

Water for the system, including ice manufacture, is obtained from an ar-

Fig. 1. Exterior View of Plant

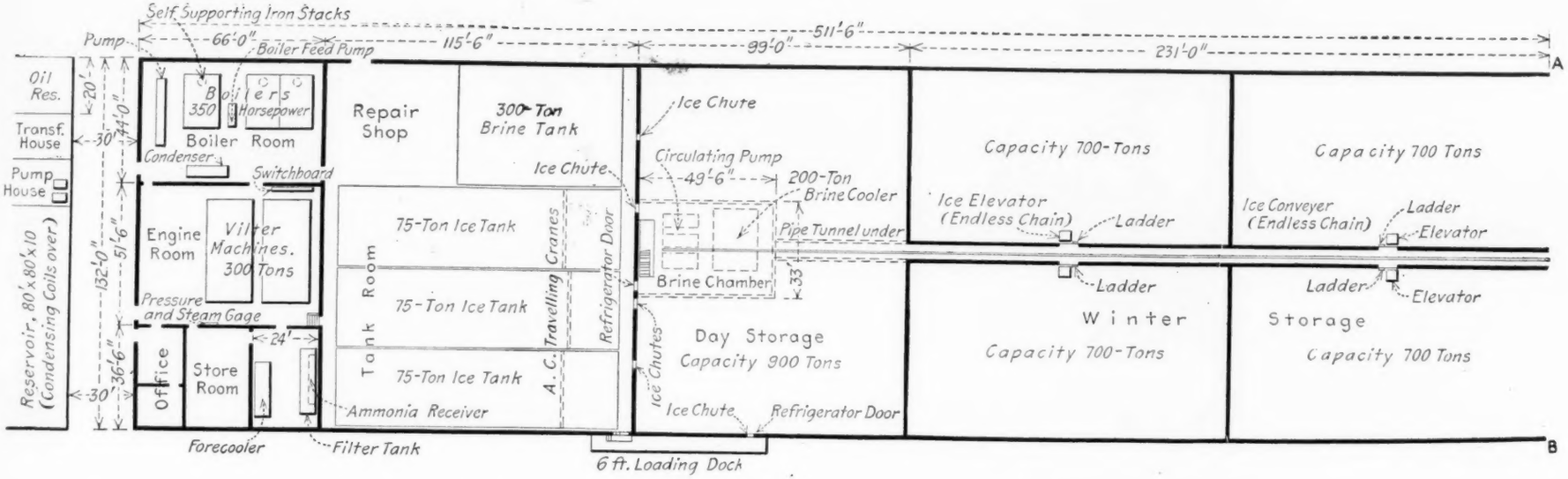
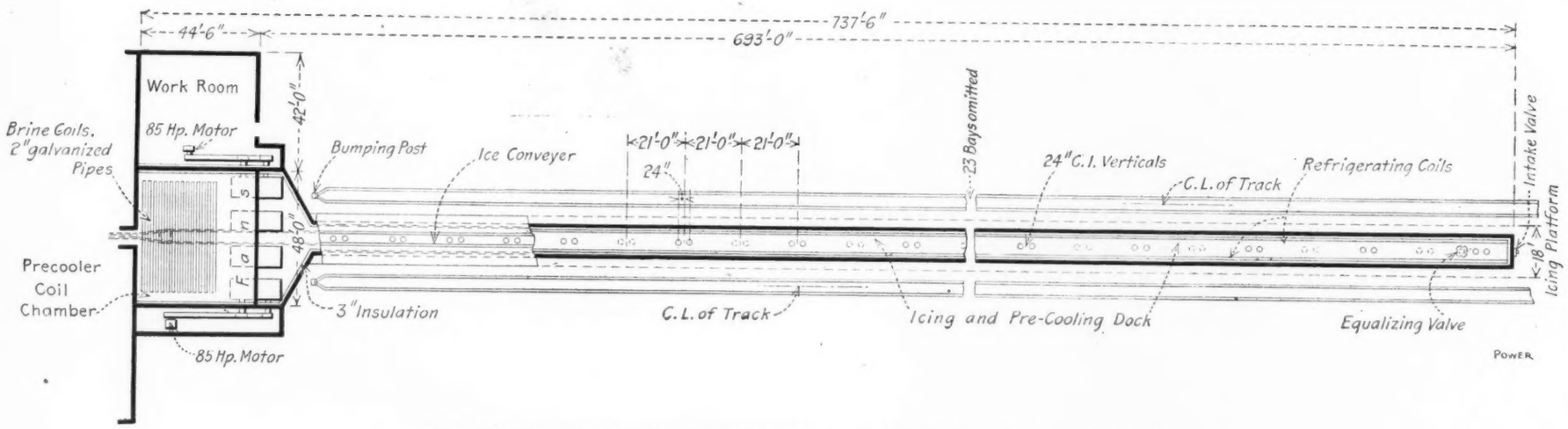


FIG. 2. PLAN OF ENGINE AND TANK ROOMS, ALSO DAY AND WINTER STORAGE



CONTINUATION FROM UPPER PLAN AT A B, SHOWING PRECOOLING COILS AND DOCK

tesian well, which is connected to the reservoir by a 14-inch steel-pipe line. This is at the surface of the ground at the well end, and enters a measuring weir at the basin end approximately 4 inches below the edge of the reservoir, giving a gradient of but 1 per cent. The flow from this well furnishes a supply of 500 gallons per minute, the normal flow being increased to this extent by an air lift, for which purpose a 4-inch air line is placed in the same trench with the water line. The pumps for this system are located in the boiler room. Fig. 1 is an exterior view of the plant.

Ice-manufacturing Plant

The installation comprises three 350-horsepower Stirling boilers, set two in a battery and one single. These furnish steam to two 24x42-inch cross-compound, Vilter corliss engines, each direct-connected to one 300-ton, 17x34-inch duplex, double-acting Vilter refrigerating machine. Adjacent to the engine room is a 36x24-foot forecooler room containing the forecooler tank, filters and ammonia receivers, the latter being placed under the filtering apparatus.

The tank chamber, shown in Fig. 3, is 115 feet 6 inches long, and extends across the full width of the building, having a ceiling hight of 21 feet, with the floor line below grade the distance noted. The floor is of concrete, covered with 2-inch corkboard over which there is a finish of 1½-inch asphalt. Three 75-ton ice-making tanks are here installed, giving a total capacity of 225 tons. The cans used are of the regulation size, 11x22x44 inches, forming 300-pound blocks, and are handled, three at a time, by electrically driven traveling cranes. One 300-ton refrigerating tank is used for the precooling system and is equipped with a Vilter flooded-ammonia system of brine coils, with an accumulator.

Storage Plant

The day-storage room is supplied with five Stevenson recording double ice chutes, a Stevenson refrigerator door and the usual storage-plant auxiliaries. It has a daily capacity of 900 tons of ice, when blocks of 300 pounds each are placed on end in one tier.

The winter storage is divided into four compartments by 6-inch concrete partitions, giving a storage capacity of about 7000 tons for each such section. Each room in the winter storage is provided with an endless-chain ice elevator for storing, and having an iron ladder for access.

Fig. 3. Tank Chamber

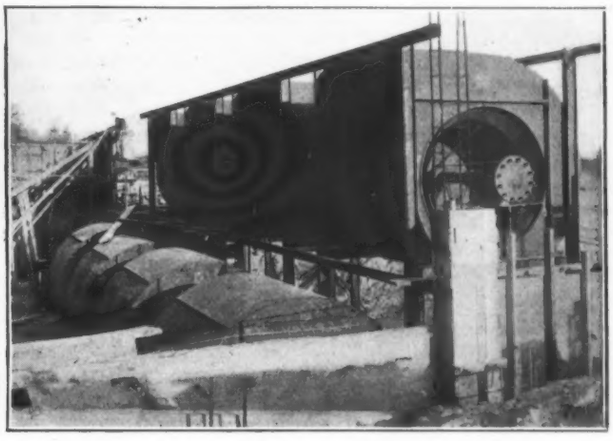


Fig. 4. Fans During Construction

Adjacent to the wall separating the tank room and day storage, and below the floor of the latter, is a 49x33x11-foot brine chamber which is shown in the sectional elevation, Fig. 5. This compartment contains a 200-ton, two-coil, double-pipe brine cooler and three electrically driven circulating pumps. The latter are interchangeable, two being used for the storage plant, or two for the precooling system, as the conditions necessitate; by this arrangement it was possible to omit a fourth pumping unit.

A concrete tunnel 8 feet wide leading from this cooling chamber extends through both storage rooms. At the end of the winter storage, the tunnel becomes a double-deck structure, the added section being of like size and construction as the lower duct, as will be noticed in Fig. 6. This lower tunnel is used for the brine mains running to the winter storage, and to the precooler coil chamber; the upper portion gives access to the winter storage and carries an endless-chain ice conveyer which leads from and through the day storage.

The entire storage plant, including the brine chamber, is insulated with 1½-inch double "Nonpareil" corkboard, with an asphalt finish 1½ inches thick on the floors. The roof is insulated with "Linofelt" and air spaces. Neither room has any outside openings, all ice being handled through the day chamber and the central tunnel in the winter-storage room.

Precooler Coil Chamber and Icing Dock

Connected by the concrete tunnels, the precooler coil chamber adjoins the winter storage. It is 44 feet 6 inches long by 48 feet wide and is insulated with 3-inch corkboard. The installation consists of a brine coil of 2-inch galvanized pipe, supported by 4-inch channel uprights and small angle brackets riveted there-

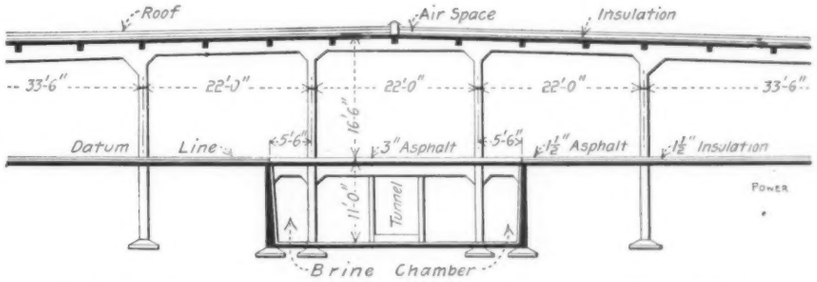


Fig. 5. Transverse Section through Day-storage and Brine Chamber

to. Eight double-inlet Sirocco fans, each about 10 feet in diameter, are arranged in two banks of four each, as shown in Fig. 4, which is from a photograph taken during the course of construction. A set of four fans, two upper and two lower on each side, is driven by an 85-horsepower motor. One bank is used for blowing, while the other is for exhausting, each function being capable of execution by either set without reversing the direction of rotation. A horizontal concrete baffle, literally a floor, is placed

between the two banks, as shown in Fig. 7.

Leading from the precooler chamber, two longitudinal concrete tunnels or air ducts extend to form the main support of the car-icing dock. These are 7 feet 6 inches and 9 feet 6 inches high respectively, and 10 feet 4 inches wide; both are of the same length, continuing the full distance, 693 feet, of the icing dock. The lower tunnel is the pressure duct, and the upper the vacuum duct, both being internally insulated with 3-inch corkboard. Refrigerating coils of 1¼-inch galvanized-iron brine pipe are arranged on both sides of either duct, a total length of about 50,000 feet being required.

Connecting to these sections by liquid-sealed revolving joints, No. 18 galvanized-iron pipes 22 inches internal diameter serve as laterals to couple the system to the refrigerator cars. This is illustrated in Fig. 9, which affords a view of the icing-dock arrangement.

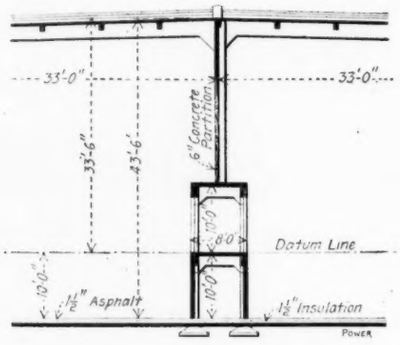


FIG. 6. SECTION THROUGH WINTER STORAGE

ELECTRIC SYSTEM

Purchasing electric current at high voltage from a central station, and stepping down to a voltage suitable for operation, the electric system offers no particular departure from ordinary practice; that is, the electrical energy is obtained at 10,000 volts and is reduced to 440 volts for motor operation, and again to 110 volts for a three-wire lighting system. The alternation of steam-driven and electrically driven auxiliary machinery, as previously indicated, permits of a continuance of operation should trouble occur at the central station.

OPERATION

The plant has a maximum precooling capacity of 32 cars, 16 on either side of the icing dock, in every four hours, or approximately 150 cars every 24 hours.

The brine is taken from the ice tanks by the circulating pumps in the brine chamber beneath the day storage, sent through its refrigerating circuit and returned to be cooled by the brine coils in the same compartment. By this refrigeration of the main ducts, the circulating air is kept in a similar state throughout its entire movement except when passing through the lateral connections to and from the cars.

A large automatic equalizing valve connecting the pressure and vacuum ducts is placed near the terminals of the tunnels. By regulation of this valve the pressure of the air delivered to the cars, and the suction at which it is withdrawn, are positively governed. The opening of this valve forms a bypass whenever the differential pressure becomes excessive, thus permitting the air to circulate through the main ducts and main cooling chamber even when no connections are made for precooling.

An automatic intake valve is located at the extreme outer end of the vacuum or low-pressure duct, as noted on the plan, Fig. 2, for the replacement of air which may be lost from the system by blowing the warm air from the cars. This is regulated to open when the vacuum falls below the differential pressure at which the equalizing valve is adjusted. The fresh air so taken into the system travels the full length of the suction duct, through the precooler coil chamber, and is then delivered to the high-pressure duct to be distributed through the cars. This insures the proper cooling of all air brought into the system from outside sources during operation.

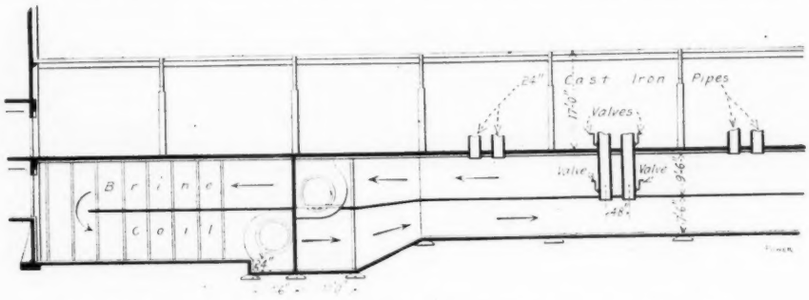


FIG. 7. SHOWING BAFFLE BETWEEN SUPPLY AND EXHAUST TUNNELS

Referring to the fan installation, the upper bank is used to exhaust from the low-pressure duct, delivering the air to the precooler coil chamber and thence over the brine coils. The other set draws the air from the coil chamber and discharges into the lower or main pressure duct for circulation through the system. The total air so handled is about 260,000 cubic feet per minute. The lower duct is held at a pressure corresponding to from ½ to ¾ inch of water above the atmosphere, and the upper at a vacuum of ½ to ¾ inch of water. Accordingly, the air is supplied to the former at a temperature of from 8 to 10 degrees, and is returned through the latter at a temperature varying from 20 to 24 degrees.

The fundamental principle of the Gay system is to secure a balanced circuit with the pressure above atmosphere in the pressure duct, practically equivalent at all times to the vacuum below atmosphere in the return on the suction duct. By this method a balanced differential air pressure directly at the ducts is obtained without the overcoming of any frictional resistance in the coil chamber. The point of equalization of the air current is thus rendered practically in the center of the refrigerator car whenever such connections may be made. Tests at the plant show that the differential pressures so equally balance during precooling as to allow the opening of the refrigerator doors, in the center of each side of the car, without any apparent loss of air to the outside, or the bringing in of any warm air, although a current of from 6000 to 8000 cubic feet per minute of cold air is passing through the cars.

Valves fitted to each lateral pipe, opening into both the pressure and the vacuum ducts as noted, secure the effect of cross connection and reversal of current, without any interchange of the laterals. These valves are of circular-disk type and of heavy construction. By employing the liquid-sealed revolving joints, universal horizontal adjustment is obtained for connecting the laterals to the refrigerator-car openings. In this manner the union can be made to an entire train without uncoupling or spotting of cars, and regardless of their various lengths. The closing connection between the lateral air pipes and the cars is accomplished by a bellows spring and scissors-lever joint, comprised of leather and iron rings, operated by a crank, as will be seen by reference to Fig. 9. This preserves the entire area of the pipe under any adjustment and makes the connection air tight almost

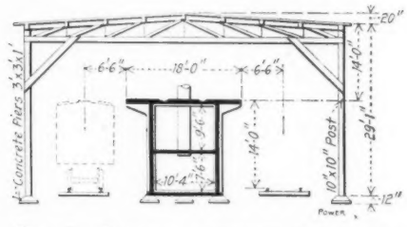


FIG. 8. SECTION THROUGH PRECOOLER AIR DUCT

instantly. The pipes themselves are absolutely air tight, being externally insulated with two layers of ¾-inch hair felt, suitably covered. By means of the universal joints they swing free of the car track when disconected. No telescope connections are employed in this system and no internal valves, the valves used being visible for constant inspection.

In practice the cars are connected as shown in Fig. 10. A funnel is placed over the bunker opening and the pressure air duct is first connected to the car for about 20 seconds. The cold air rushing in quickly displaces the warm air and vapors cast off by the fruit; these vapors are allowed to escape through the ice-bunker trap door at the opposite end. The lateral from the suction duct is then joined to the ice-bunker opening at this end of the car, and circulation is established. During the cooler seasons of the year both connections are made simultaneously. The differential pressures, of course, control the speed with which the air passes; the violence of the current permeates to the center of every package, which is an essential consideration in proper precooling.

The total amount of refrigeration consumed by a car of fruit averages about 3 tons, or 1½ tons ice equivalent, depending upon the initial temperature of the fruit, which, varying with the season of the year, may cause this amount to become as low as 1½ tons or as high as 4 tons. The amount of air circulating through each car in a period of four hours approximates 1½ million cubic feet. When the plant is running at maximum capacity the amount of air circulated through each car per minute is about 8000 cubic feet, with an average loss not exceeding 5 per cent. The cars are cooled to about 40 degrees Fahrenheit.

For icing the cars, upon the completion of precooling, or for such cars as are not precooled, the ice is handled by the endless-chain conveyer running through the day and winter storage. Here it may be diverted or carried on to the dock, the conveyer traversing the full length on both sides and making the ice accessible for immediate loading.

The plant is provided with facilities for metering all the brine used in precooling, and in cooling the ice-storage chambers, also with thermometers giving the temperatures at all such places. Barometric columns are installed in the main air ducts and laterals, showing the pressure at which the air is circulated and returned. To afford a complete refrigerating record on every car handled, the velocity of air in both feed and return laterals is measured.

A brine system of refrigeration has its advantages in precooling work. During the period of changing trains and other intermissions the plant is given an opportunity to store up cold brine, placing it in a position to properly handle the large refrigerating demands made when a full load is incurred. The original charge of ammonia at the Santa Fé plant was about 13,000 pounds, and during its period of operation this has been added to but slightly.

The plant represents an investment of about $900,000. The special features of the system installed are the combination of an ice-manufacturing and precooling plant in the same structure, the avoidance of loss of refrigerated air either by leaking out of the car, or by drawing outside air into the car, and the application to one or more cars at the same time with identical treatment, with the addition of effecting the precooling service without any alterations in the standard refrigerator car.

The writer desires to mention the courtesy of the Santa Fé Railway extended in an inspection of the plant and the information accorded by C. M. Gay.

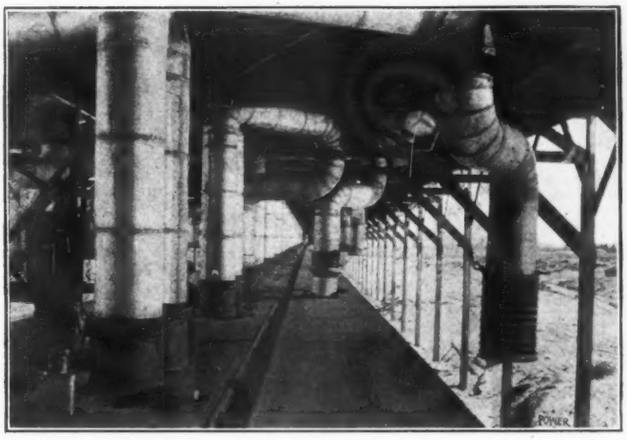


FIG. 9. SHOWING METHOD OF ATTACHMENT TO CARS

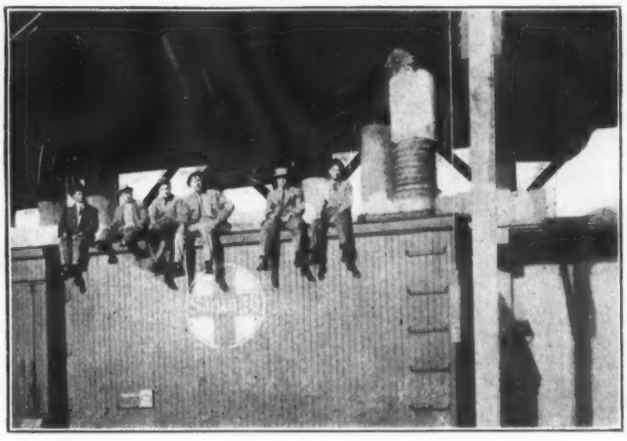


FIG. 10. CAR DURING PRECOOLING

The Cunard liner "Aquitania" when completed will be 865 feet long, exceeding the present largest steamship, the "Olympic," by 12 feet 6 inches.

A Timely Rescue

BY D. L. FAGNAN

I had just finished putting in a 100-ton refrigerating machine. The plant had been tested and accepted, and the erecting engineer and myself were ready for the return trip. It was about four hours until train time, so we decided to visit a brewery where machines had been recently installed. While looking over the plant a boy ran up to us and cried: "The ammonia has busted!"

As we rushed to the engine room the lad told me that the engineer was in alongside the tanks (the receivers were in an alleyway by the side of a brine tank). I grabbed an old jumper and wetting it in a barrel which stood near, started for the passageway. Groping around, I got hold of the engineer and dragged him to the door. He had inhaled the green ammonia and was unconscious. I soon had to drop my hold, but the erecting man came to my assistance and the engineer was finally pulled out. His hands, face and eyes were burned, and his chest was dripping with clear ammonia. Some vinegar was found and dashed in his face, mouth, eyes and over his chest and hands; then cold water was poured over him. When it was seen that the man was recovering, it was up to us to stop the leak.

As we did not know what had happened, it was decided to shut all the valves. This was no easy task as the odor was unbearable. In a few moments all valves on the condensers, liquid lines, expansion coils and section lines from the cellars were closed. When it was possible to get into the room where the accident had occurred a stillson wrench was found on the floor; the engineer in attempting to screw down a valve nut had stripped the threads. Barely two threads had been caught properly, and the strain was too much. He had also placed one ring of packing too many in the valve during erection. Nearly half a drum of ammonia was lost.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

The Improved Glafke Oil Burner

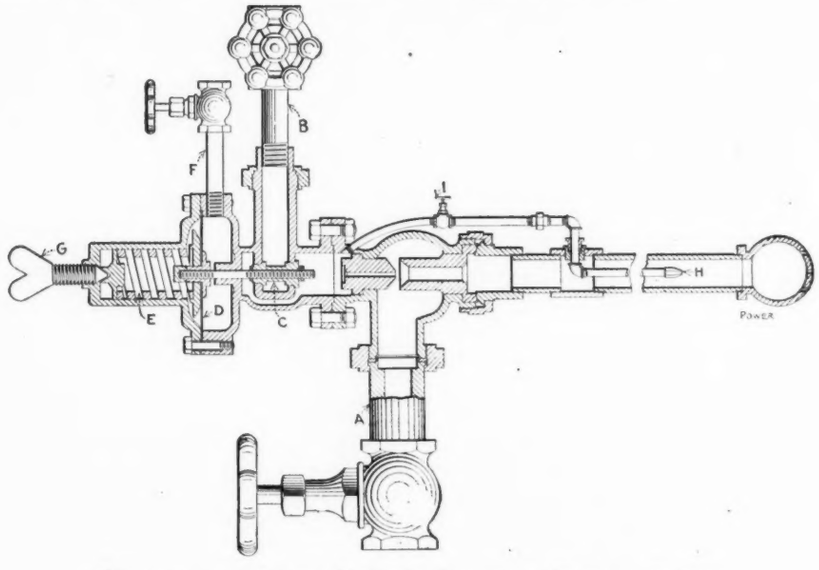
It is claimed by its makers that the improved Glafke automatic vacuum oil burner is the only one on the market which requires no pump. This burner is designed on the ejector principle; the oil condenses part of the steam, thus creating a vacuum in the suction line by which the oil is lifted from the storage tank.

The steam supply to the burner, and hence the quantity of oil fed to the furnace, is regulated by the steam pressure in the boilers. The manner in which this is accomplished is shown in the accompanying figure.

The oil-suction line is at *A* and the steam-supply line at *B*. The steam is admitted to the mixing chamber through the double-ported valve *C*. The stem of this valve passes through a stuffing box and connects with the diaphragm *D*. The spring *E* acts upon this diaphragm on one side and the full steam pressure of the boiler, admitted to the diaphragm chamber through pipe *F*, on the other. Thus, as the boiler steam pressure decreases, the spring acts on the steam-supply valve, causing more steam to be admitted to the burner, which in turn increases the quantity of oil fed to the furnace. As the boiler pressure increases it tends to overbalance the pressure of the spring and close the steam-supply valve, thereby reducing the fire.

The operation of the burner is regulated by changing the tension of the spring by means of the thumb screw *G*. Once the burner is adjusted it requires no further attention.

The auxiliary steam nozzle *H* serves to better atomize the oil and to produce the lifting vacuum more quickly when starting up. The steam to this nozzle is regulated by the valve *I*.



DESIGN OF THE GLAFKE IMPROVED AUTOMATIC FUEL-OIL BURNER

The following are some of the points claimed for the Glafke burner by its manufacturers, the Glafke Company, 168 Second street, San Francisco, Cal.:

Exceptionally low cost of installation due to the elimination of the oil pump and the extra piping it requires. A saving in the maintenance and in the quantity of steam chargeable to the burner system for the same reason. Automatic, close maintenance of predetermined boiler pressure for wide range of load.

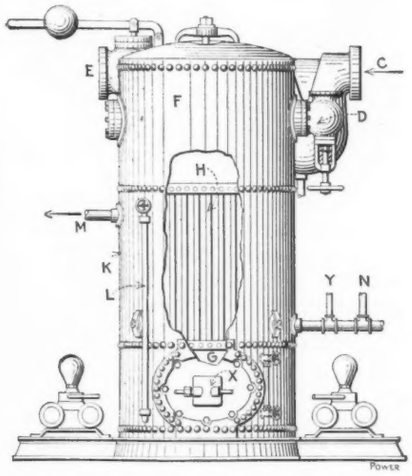
The burner is sold under a broad guarantee.

Connell's Automatic Receiver, Steam Drum and Water Heater

The combined automatic receiver, steam drum and water heater illustrated herewith was designed with a view to economy of space and for this reason it is especially adapted for use in the plants of office buildings, hotels, hospitals, apartment houses and similar buildings where available space is often limited. The heater supplies water for boiler feed, house service or any other purpose as desired.

Exhaust or live steam, as the case may be, is admitted at the back of the steam drum *F* after passing through the separator *C*. The relief valve *E* prevents the pressure in the drum from exceeding the predetermined degree. Connection to the house-heating system may be made through valve *D* when desired.

The condensed steam falls through the tubes *H* into the hotwell *G* to the bottom of which connections are made with the boiler-feed pumps. The part *K* constitutes the water heater. The cold water, supplied from either the house tank or the city mains, enters through *N*. The hot water for the house service leaves through connection *M* and the returns enter through *Y*. Makeup water for boiler feed is supplied to the hotwell through the connection *L*. There is an atmospheric float arrangement at *X* which if it is desired may be connected to a suitable valve in *L* so that the makeup water will be supplied automatically.



CONNELL'S RECEIVER AND HEATER

Besides its simplicity and the economy in space which it effects, it is claimed that this apparatus makes the best and most logical use of the steam because the steam always comes in contact with the hottest water first. The apparatus is manufactured and marketed by its inventor, John F. Connell, 324 Stimson building, Los Angeles, Cal.

Macdonald Shaking Grates

The Macdonald shaking grate made by the Robb Engineering Company, of South Framingham, Mass., is so designed that the tilting of the sections improves combustion by giving a maximum irregularity of surface for breaking up clinker and the mass of unburned fuel, but does not open up wide spaces which would allow unburned coal to fall into the ashpit. The detachable top sections may be easily changed for altering the air openings or for renewal. When in an operating position the grate is flat and is locked in place, as shown at the left of Fig. 1. The surface of the grates cannot be left uneven with points projecting into the fire for it is only when they are level that the lever can be disengaged.

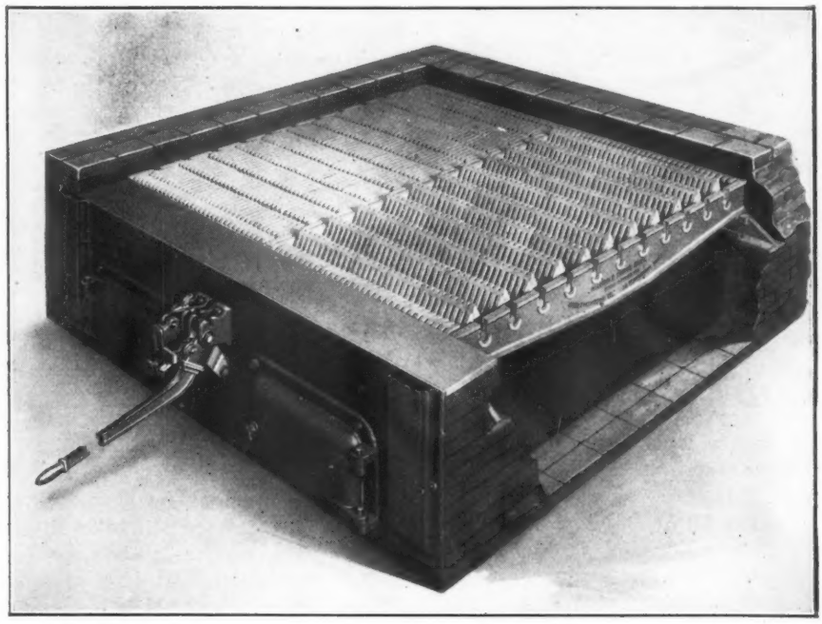


FIG. 1. GRATES TILTED AND LOCKED IN FLAT POSITION

To give greater irregularity of surface the points of the triangles are made to penetrate deeply into the body of the fire, thus allowing proper air circulation. The mechanism is so arranged that when the lever is operated the top surfaces of the triangular sections are 60 degrees from the horizontal, as shown in Fig. 2, and the lever can be swung through an arc of about 60 degrees. Because of the equilateral-triangle construction of the sections and the fact that the tilting of the sections is entirely in one direction, the spaces between the grate sections at the end of the stroke are exactly the same as at the beginning, and during the whole movement there is practically no variation in the size of the spaces.

This grate is made up of small removable sections which securely fit the rocking bars and can be easily removed. These sections can be furnished with any desired air space and can be replaced, when it is advisable to change the grade of coal used, without altering the rocking and supporting bars or operating mechanism. When necessary, a few sections may be replaced without renewing the whole grate when perhaps only a small part is burned out. This design minimizes the cost of repairs and permits keeping the grates in their best working condition.

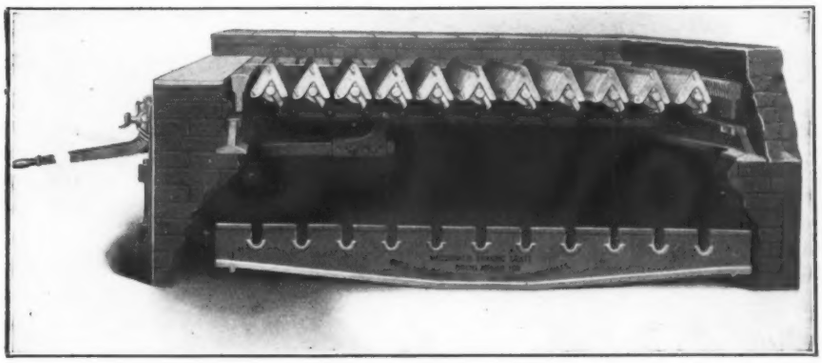


FIG. 2. HOW TRIANGULAR SECTION CAN BE TILTED

This grate is locked in a horizontal position and cannot be moved until the shaking lever is inserted and locked in place, as shown in Fig. 3, which movement unlocks the grate. Unlocking the bell crank so that the grates may be shaken locks the operating lever, and the only position in which the cam may be thrown down so as to disengage the lever is when the grates are level.

A remarkably quick piece of repair work was recently done by the Harris Engineering Company, of Providence, R. I. About 11 a.m., Friday, they were notified by the Akela mills, of Pascoag, that the frame of their engine had broken. A man was at once despatched to Pascoag, where he found the large two-ton frame casting in the engine, a Harris-Corliss of 200 horsepower, broken. The engine had been running with a heavy load for 35 years. Fortunately the Harris company had an old engine of that type on the floor of its plant, and the frame was taken from it, placed on a five-ton automobile truck and taken over the 25 miles of road to Pascoag. At midnight Saturday the machinist was taken to Providence by automobile to get some fittings, returning at daylight, and the engine was ready to start up Sunday morning.

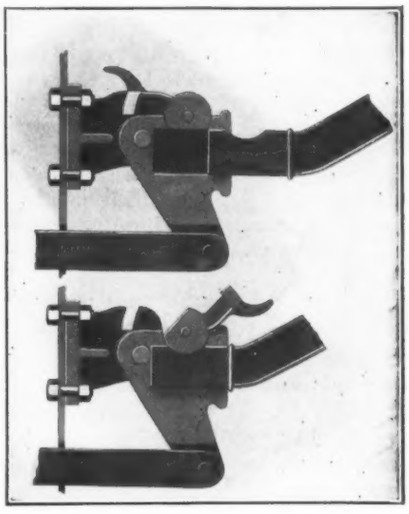


FIG. 3. LOCKING DEVICE

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

"Anybody who can write, can write an advertisement. But the question is whether it will sell anything or not," was the statement of one of the biggest general-magazine advertisers of the country the other day.

Is this a fact?

Is a set of rhymed words that looks like a poem when printed on a page, but that never stirs anyone to an iota of feeling, a poem? Is a brain which never thinks, a brain? Is a salesman who never sells anything a salesman?

We don't think so; neither do we think a half-page or a page or a double page of words about something that is to sell, but which never induces anyone to buy it or investigate it, an advertisement.

An advertisemen means at core a thing that makes somebody *turn to* something.

If the advertisement is worth its name, it will *turn* certain people who are interested in that class of goods *to* the particular representative of that class it refers to. It turns them because it makes them see in that product some certain characteristic that, they think, would constitute it their most profitable investment. And if the investigation verifies this impression, such "turnings-to" mean sales.

That is an advertisement.

And herewith another thing becomes apparent:

A real advertisement cannot be written about inferior goods.

When you see an advertisement, so called, that is all vacuous general statements, you can be sure of one of a brace of things:

Either the subject under discussion won't bear scrutiny.

Or the author of the copy didn't know how to write an advertisement.

You can't go to particulars about goods whose makers have spent most of their time in building up the glossed-over impression that their goods are as good or better than the next man's "because they are." It is the particulars behind the "because" that the latter-day buyer is wrapped up in.

Particulars sting down to those little differences, *and to the big differences which the little ones hide*, that appeal to the man who thinks before he acts, and who pays small attention to an advertisement that does not make him think. Such a man is quite apt to believe that "wide-as-the-sky" statements are the refuge of the lagger.

Of course they may not be.

Poor advertisements can be written about good products, and those same goods sell mightily, too. They may have no competition, or no competition at all in quality, or else the sales may be impelled by costlier ways of publicity for which the buyer foots the bill in the end.

All this gets us to our point:—

POWER advertisements not only tell the truth, *but most of them tell it so as to bring action.*

"Two and two make four" is true enough; but its repetition has no value—it *does* nothing.

"This machine is right for you because it is this and this, and this, and does this"—*that* can be both true and be written in such a way as to create instant desire to see, to investigate, to buy that machine.

We, the Service Department men who write POWER advertisements, are trained to take advantage of this one big opportunity—that, in the case of a specialized paper like POWER, every individual of our multiplied print-salesman goes *direct to a buyer or a person concerned or interested* in the buying of the thing advertised. We know every lost word may mean a lost sale.

We write these advertisements fully as much to serve you as to serve the advertiser whose goods they describe. There is where the full idea of "service" comes in.

When we put together a convincing advertisement that turns you to investigate something in POWER Selling Section and then, quite likely, to buy that thing, we perform a service for you by getting you to as efficient, or the most efficient machine, appliance, whatever it be, that the market can give you —without the "exploration-worry" on your own part after a thing that is at once reliable and suited for the immediate purpose.

POWER advertisers hand over to us the writing of their advertisements because they feel we can do it most effectively; they give us their confidence.

And just as this confidence is thrown to the winds unless we write these advertisements effectively, convincingly, so this effectiveness goes to the winds unless the advertisements are *read.*

POWER advertisements are for you, and when you read them and act on them, *you serve yourself.*

Boiler Explosion in Sugar Factory

On November 1, a boiler exploded at the factory of the Mt. Clemens Sugar Company, Mt. Clemens, Mich. Three men were reported to be seriously injured. A detailed account of the explosion will be given in an early issue.

SOCIETY NOTES

At a meeting of the executive committee of the Master Boiler Makers' Association, held at the Fort Pitt hotel in Pittsburg, Saturday, October 28, it was unanimously decided to hold the sixth annual convention of this association in Pittsburg, May 14 to 17 inclusive, 1912. The Fort Pitt hotel will be the headquarters.

At the first meeting of the American Society of Mechanical Engineers in New York City on November 14, three papers will be presented on autogenous welding. H. R. Cobleigh will talk on the origin and principles of each process, G. E. Pelissier will discuss thermit welding, and electric welding will be treated by C. B. Auel. Some interesting discussion may also be expected.

BUSINESS ITEMS

Among recent orders taken by Frank L. Patterson & Co., 28 Cortlandt street, New York, for the different types of Patterson hot-water heaters are Emporium department store, St. Paul, Minn.; Sage Foundation buildings, Forest Hills, L. I., N. Y.; Sidney Blumenthal & Co., dye house, Shelton, Conn.; Shorter College, Rome, Ga.; Woodward office building, Washington, D. C.; Bender hotel, Houston, Tex.; Wellesley College, Wellesley, Mass.; Bland hotel, Raleigh, N. C.; William Edwards Company, wholesale grocers, Cleveland, Ohio; Yonkers Nursery Company, Yonkers, N. Y.; Hampton Normal and Agricultural Institute, Hampton, Va.; Young Men's Christian Association, Baltimore, Md.; University of Pennsylvania, Philadelphia, Penn.; Tuberculosis hospital, Farmingdale, N. J.; Baltimore hotel, Kansas City, Mo.; Springfield State asylum, Sykesville, Md.; Castle Inn, Delaware Water Gap, Penn.

ENGINEERS WANTED

Under this head are published, without charge, advertisements of actual vacancies in power plants for operating engineers and assistant engineers. For the guidance of applicants for advertised positions, the advertisements must contain particulars to show the class of service demanded and the wages paid. Employers who desire to advertise under this head are requested to write for a blank form of application.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Thoroughly competent steam specialty salesman: one that can sell high-grade goods. Address "M. M. Co.," POWER.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

THE VULCAN SOOT CLEANER offers an exceptional opportunity for power specialty salesmen. For further particulars address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

REPRESENTATIVE WANTED to handle blowers, feed water regulators, ventilating fans and positive pressure blowers in various localities on commission. Address Wing Mfg. Co., 90 West street, New York.

ONE ENGINEER in each town to represent us, your choice of any indicator outfit on the market as a free premium; give your home address and firm employed by. The Olson Mfg. Co., Manitowoc, Wis.

AGENTS WANTED—To sell lubricating oils, belts, hose, paint and varnish, for power machinery, to factories, mills, auto owners, stores, threshers; exclusive territory to right party; oil experience unnecessary. Manufacturers Oil & Grease Co., Cleveland, Ohio.

A PRACTICAL OR TECHNICAL MAN with $5,000 to $10,000 wanted to take an active part in an incorporated engineering company in New York City, requiring more capital to extend their business. Stock will be issued for the investment and salary paid. Address POWER, Box 527.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

GAS ENGINEER open for position, 10 years' experience with gas engines, electrical machinery, bituminous and wood burning gas producers, can take charge of any size plant, executive ability, fluent Spanish, ready to go anywhere. Box 522, POWER.

ENGINEERING SALES AGENT solicits additional high grade lines of interest to power plants, railways, gas and water companies for Chicago and Middle West; can exploit your line with intelligence; have designing and construction knowledge in addition to sales ability. Address Box 528, POWER.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS—C. L. Parker, Patent Attorney, ex-examiner Patent Office, 904 G St., Washington, D. C. Write for Inventor's Handbook.

ENGINEERING SALES AGENT wishes a live qualified party to join him in operating a sales office (Chicago territory) for mechanical equipment and supplies for power plants and public utilities. Box 592, POWER.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1417 W. Jackson Blvd., Chicago, Ill.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—One single cylinder, 66 horsepower gas engine and producer; made by the Power and Mining Machinery Co. Avery Scale Co., North Milwaukee, Wis.

FOR SALE—14"x26"x18" cross compound "Fleming" Harrisburg engine. Three 150-horsepower Manning boilers, stack and feed water heater. J. F. Foster, 166 Devonshire St., Boston, Mass.

FOR SALE—8x10 Skinner engine, direct connected to 30-kilowatt generator, and 8x10 Allfree engine, direct connected to 20-kilowatt generator. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

50-KILOWATT GENERATOR, direct connected to Ball engine; 75-kilowatt direct to Ideal, 100-kilowatt direct to Cooper, 18x36 and 20x42 heavy duty Corliss engines, 60x16 and 72x18 Butt Strap boilers. Others at very low prices. Hugh W. Dyar, 140 South Dearborn Street, Chicago, Ill.

TWO SETS (two wheels to each set) Hercules, bronze water wheels, with wheel cases; wheels 24 inches diameter, on horizontal shafts; made by Holyoke Machine Company; capacity, approximately 600 horsepower, under 50 feet head; in good condition, having been used less than five years. J. E. Henry & Sons Co., Lincoln, N. H.

FOR SALE—Two sets of American Blower Company fan blowers complete with engines. Fans, 60 inches in diameter, 24 inches wide, 400 revolutions per minute. Engines, single cylinder, horizontal 8x10-inch, 210 revolutions per minute. Also, one type 7–2P Stanley Electric Manufacturing Company generator having a speed of 600, volts 2400, kilowatts 200, alternations 7200. Box 526, care POWER, 122 S. Michigan Blvd., Chicago, Ill.

RECEIVER'S SALE—The entire plant and business of the Holbeck-Riverside Gas Power Company, manufacturers of the famous RIVERSIDE GAS ENGINE, a modern type engine protected by patents, with concrete and brick shops, located at Oil City, Penn., fully equipped with modern machinery, will be sold at low price if disposed of within thirty days. For testimonials and further particulars inquire of Oil City Trust Company, Receiver, Oil City, Penn.

ALPHABETICAL INDEX TO ADVERTISERS

	PAGE
Albany Lubricating Co.	117
Alberger Pump Co.	119
Allis-Chalmers Co.	144
American District Steam Co.	132
American Eng. Co.	141
American Injector Co.	124
American Mfg. Co.	88
American Metal Hose Co.	121
American School of Corres.	101
American Ship Windlass Co.	105
American Steam Gauge and Valve Mfg. Co.	66, 67
Ames Iron Works.	144
Anderson Co., V. D.	98
Armstrong Mfg. Co.	104
Armstrong Mfg. Co., The	108
Ashcroft Mfg. Co., The	90
Ashton Valve Co.	95
Austin Separator Co.	98
Babcock & Wilcox Co.	125
Ball Engine Co.	145
Baragwanath & Son, Wm.	86
Barnes Co., W. F. & John	132
Beggs & Co., James	131
Betson Plastic Fire Brick Co.	75
Bignall & Keeler Mfg. Co.	116
Blake & Knowles Steam Pump Works	119
Bogart Gas Power Engineering Co.	139
Bowers Rubber Works	107
Branch School of Engineering, Joseph G., The	116
Bristol Co.	4th cover
Bruce-Macbeth Engine Co.	134
Buckeye Engine Co.	142
Buffalo Steam Pump Co.	122
Builders Iron Foundry	82
Burt Mfg. Co.	16
Cameron Steam Pump Works, A. S.	120
Cancos Mfg. Co.	106
Carb-Ox Co.	126
Casey-Hedges Co.	125
Chaplin-Fulton Mfg. Co.	127
Chapman Valve Mfg. Co.	97
Chesterton Co., A. W.	72
Columbian Rope Co.	88
Commercial Milling Co.	75
Connersville Blower Co., The	88
Consolidation Coal Co.	13
Consolidated Safety Valve Co.	90
Cooley & Milligan	97
Cooper Co., C. & G.	138
Crescent Belt Fastener Co.	87
Cresson Co., Geo. V.	88
Crosby Steam Gage & Valve Co.	77
Curtis & Curtis Co.	81
Dallett Co., Thos. H.	76
Dart Mfg. Co., E. M.	97
Deane Steam Pump Co.	121
Dearborn Drug & Chemical Works	5
De La Vergne Machine Co.	138
Deming Co.	122
Detroit Lubricator Co.	116
Diamond Power Specialty Co.	80
Diamond Rubber Co.	108
Dixon Crucible Co., Jos.	116
Edge Moor Iron Co.	124
Electric Weighing Co.	80
Elliott Co.	7
Engineers Appliance Co., The	94
Epping-Carpenter Co.	121
Eureka Packing Co.	79, 109
Fitchburg Steam Engine Co.	141
Flexible Steel Lacing Co.	86
Fort Wayne Electric Works.	133
Foster Engineering Co.	94
Franklin Oil Filter Co.	112
Garlock Packing Co.	9
Gas Power Machinery Co.	135

PAGE

Golden-Anderson Valve Specialty Co. 96
Graspit Mfg. Co. 106
Graver Tank Works, Wm. 110
Green Engineering Co. 102
Greene, Tweed & Co., 112, 4th cover
Griffith & Wedge Co. 141
Griscom-Spencer Co. 84

Hammel Oil Burner Co. 88
Hancock Inspirator Co. 90
Harbison-Walker Refractories Co. 129
Harris Steam Engine Co., W. A. 144
Harrisburg Fdry. and Mach. Works 141
Harrisburg Mfg. & Boiler Co. . 124
Harrison Safety Boiler Wks. . 69
Hayden & Derby Mfg. Co. 90
Heine Safety Boiler Co. 124
Hewes & Phillips Iron Wks. . . 140
Hoffman, Geo. W. 132
Holyoke Steam Boiler Works, Inc. 125
Homestead Valve Mfg. Co. ... 94
Hooven, Owens, Rentschler Co. 141
Hoppes Mfg. Co. 82
Howard Iron Works 84
Hughson Steam Specialty Co. 94
Huyette Co., Inc., Paul B. . . . 121

Ingersoll-Rand Co. 78
International Corr. Schools . . . 73
International Harvester Co. of America 137

Jefferson Union Co. 89
Jeffrey Mfg. Co. 101
Jenkins Bros. 71
Johns-Manville Co., H. W. . . . 107

Keeler Co., E. 126
Kellogg Co., The M. W. 109
Kennicott Co., The 127
Keystone Lubricating Co. 3
Kincaid Bros. 96

PAGE

Kinkead Mfg. Co. 110

Lagonda Mfg. Co. ..... 3d cover
Laidlaw-Dunn-Gordon Co. 140
Liberty Mfg. Co. 7
Locke Regulator Co. 106
Lord Co., Geo. W. 75
Long Grate Bar Co. 102
Lunkenheimer Co. 4
Lytton Mfg. Corporation 100

McClave-Brooks Co. 12
McGowan Co., The John H. . . 120
McGraw-Hill Book Co. 130
McIntosh, Seymour & Co. 142
McLeod & Henry Co. 128
Magnolia Metal Co. 134
Main Belting Co. 85
Manzel Bros. Co. 112
Martin Grate Co. 103
Mason Regulator Co. 91
Mellor Furnace Engr. Co. 127
Minneapolis Steel & Mach. Co. 137
Monarch Valve & Mfg. Co. ... 93
Morehead Mfg. Co. 98
Morrin Climax Boiler Co. 125
Murphy Iron Works 104

Nashua Machine Co. 98
National Pipe Bending Co. ... 86
National Tube Co. 75
Neemes Bros. 104
Nelson Valve Co. 92
New Bedford Valve Mfg. Co. . 94
New Process Raw Hide Co. . . 88
New York & New Jersey Lubricant Co. 115
New York Belting & Packing Co., Ltd. 10
New York Edison Co. 134
Newhall Eng. Co., Geo. M. . . . 99
Northern Equipment Co. 126
Nugent & Co., Wm. W. 112

Ohio Blower Co. 138
Ohio Injector Co. ..... 4th cover
Ohio Brass Co. 109
Oil City Boiler Works 126

PAGE

Open Coil Heater & Purifier Co. 97
Otto Gas Engine Works 139

Parson Mfg. Co. 104
Patterson & Co., Frank L. . . . 83
Peerless Rubber Mfg. Co. 8
Penberthy Injector Co. 11
Pennsylvania Flexible Metallic Tubing Co. 134
Perfection Grate Co. 104
Perkins Co., Jno. B. 97
Perolin Co. of America 108
Pierce Co., Wm. B. . 2nd cover
Pittsburgh Valve, Fury. and Construction Co. 97
Power & Mining Machry. Co. . 139
Power Specialty Co. 108
Precision Instrument Co. 126
Providence Engineering Wks. . 140

Quimby, Inc., Wm. E. 122

Reliance Gauge Column Co. ... 127
Remington Oil Engine Co. ... 136
Richardson-Phenix Co. 111
Ridgway Dynamo and Engine Co. 141
Robb Engineering Co., Ltd. . . 123
Robertson & Sons, Jas. L. . . . 79
Rogers Co., H. A. 140
Rollins Engine Co. 143
Rooksby & Co., E. J. 142

"S-C" Regulator Co. 127
St. John, G. C. 132
Salamander Grate Bar Co. ... 104
Scaife & Sons Co., Wm. B. ... 126
Schade Valve Mfg. Co. 95
Schaeffer & Budenberg Mfg. Co. 110
Schieren Co., Chas. A. . 1st cover
Schuchardt & Schutte 110
Schutte & Koerting Co. 106
Simonds & Co., G. L. 125
Skinner Engine Co. 141
Smith & Son Co., Samuel 125
Smooth-On Mfg. Co. 6
Squires Co., C. E. 101

PAGE

Standard Grate Co. 104
Starrett Co., L. S. 102
Steel Mill Packing Co. 108
Stewart Co., The Paul B. 75
Struthers-Wells Co. 138
Sturtevant Co., B. F. 84

Terry Steam Turbine Co. 132
Tillotson Humidifier Co. 100
Toledo Pipe Threading Machine Co. 141
Treadwell Co., Inc., M. H. 102
Trill Indicator Co. 77
Trimont Mfg. Co. 118
Turbo-Blower Co. 110
Turner-Fricke Mfg. Co. 139

Uehling Instrument Co. 126
Under-Feed Stoker Company of America 104
Underwood & Co., H. B. 144
United States Graphite Co. ... 114
Universal Lubricator Co. 113

Vilter Mfg. Co., The 140
Vogt Mach. Co., Inc., Henry . . 124
Von Kokeritz & Co., R. G. 82

Walker & Co., Ltd., James . . . 108
Walton Co., F. S. 14, 15
Warren, Webster Co. 74
Washburn & Granger 102
Watson & McDaniel Co. 122
Watts-Campbell Co. 142
Western Electric Co. 75
Westinghouse Machine Co. 146
Wheeler Condenser & Engr. Co. 121
Wheeler Mfg. Co., C. H. 122
Whitlock Coil Pipe Co. 86
Wickes Boiler Co. 126
Williams & Co., J. H. 113
Wing Mfg. Co., L. J. 96
Wisconsin Engine Co., The . . . 138
Worthington, Henry R., ... 120
Wright Mfg. Co. 98

Yale & Towne Mfg. Co. 121
Yarnall-Waring Co. 81

CLASSIFIED INDEX TO ARTICLES ADVERTISED

Air Compressors

Allis-Chalmers Co. 144
De La Vergne Machine Co. 138
Ingersoll-Rand Co. 78
Laidlaw-Dunn-Gordon Co. 140
Perkins Co., Jno. B. 97
Vilter Mfg. Co. 140

Air Cooling Apparatus

De La Vergne Machine Co. 138

Alarms, Low Water

Detroit Lubricator Co. 116
Elliott Co. 7
Lunkenheimer Co. 4
Penberthy Injector Co. 11
Reliance Gauge Column Co. . . 127
Wright Mfg. Co. 98

Alternators

Allis-Chalmers Co. 144

Ash Ejectors

Parson Mfg. Co. 104

Bearing

Cresson Co., Geo. V. 88

Belt Dressing

Dixon Crucible Co., Jos. 116
Graspit Mfg. Co. 106
Garlock Packing Co. 9
Keystone Lubricating Co. 3
Robertson & Sons, Jas. L. 79
Schieren Co., Chas. A. . . 1st cover
Smooth-On Mfg. Co. 6
Walton Co., F. S. 14, 15

Belt Fasteners

Crescent Belt Fastener Co. 87

Belt Lacing

Bristol Co. ..... 4th cover
Flexible Steel Lacing Co. 86
Schieren Co., Chas. A. . . 1st cover

Belt Tighteners

Cresson Co., Geo. V. 88

Belting

Bowers Rubber Works. 107
Diamond Rubber Co. 108
Garlock Packing Co. 9
Greene, Tweed & Co., 112, 4th cover
Jeffrey Mfg. Co. 101
Main Belting Co. 85
New York Belting & Pack. Co. 10
Peerless Rubber Mfg. Co. 8
Schieren Co., Chas. A. . . 1st cover

Blocks, Chain

Yale & Towne Mfg. Co. 121

Blowers, Fan

Beggs & Co., James. 131
Ohio Blower Co. 138
Sturtevant Co., B. F. 84
Terry Steam Turbine Co. 132
Turbo-Blower Co. 110
Wing Mfg. Co., L. J. 96

Blowers, Steam Jet

Beggs & Co., James. 131
McClave-Brooks Co. 12
Parson Mfg. Co. 104
Schutte & Koerting Co. 106

Boiler Compound

Dixon Crucible Co., Jos. 116
Dearborn Drug and Chemical Works 5
Elliott Co. 7
Johns-Manville Co., H. W. 107
Keystone Lubricating Co. 3
Lord Co., Geo. W. 75
Perolin Co. of America 108
United States Graphite Co. 114

Boiler Fronts

Casey-Hedges Co. 125

Boiler Setting

Betson Plastic Fire Brick Co. . 75
Harbison-Walker Refractories Co. 129
McLeod & Henry Co. 128

Boiler Tube Cap Reseating Machine

Elliott Co. 7
Lagonda Mfg. Co. ..... 3d cover
Liberty Mfg. Co. 7
National Tube Co. 75

Boiler Tube Cleaners

Dalleff Co., Thos. H. 76
Garlock Packing Co. 9

Boiler Tubes

National Tube Co. 75

Boilers

Ames Iron Works. 144
Babcock & Wilcox Co. 125
Beggs & Co., James. 131
Casey-Hedges Co. 125
Edge Moor Iron Co. 124
Griffith & Wedge Co. 141
Griscom-Spencer Co. 84
Harrisburg Foundry & Mach. Works 141
Harrisburg Mfg. & Boiler Co. . 124
Harrison Safety Boiler Wks. . 69
Heine Safety Boiler Co. 124
Hewes & Phillips Iron Wks. . . 140

Boilers—*Continued.*

Holyoke Steam Boiler Works, Inc. 125
Keeler Co., E. 126
Kennicott Co. 127
Minneapolis Steel & Mchy. Co. 137
Morrin Climax Boiler Co. 125
New Bedford Valve Mfg. Co. . 94
Oil City Boiler Works. 126
Perkins Co., Jno. B. 97
Robb Engineering Co., Ltd. ... 123
Smith & Sons Co., Samuel. 125
Struthers-Wells Co. 138
Vilter Mfg. Co. 140
Vogt Machine Co., Henry. 124
Wickes Boiler Co. 126

Books

American School of Corres. . . 101
International Corr. Schools. . . 73
McGraw-Hill Book Co. 130

Brick, Fire

Harbison-Walker Refractories Co. 129
McLeod & Henry Co. 128

Calorimeters

American Steam Gauge and Valve Mfg. Co. 66, 67

Castings, Brass and Iron

Bruce-Macbeth Eng. Co. 134
Builders Iron Foundry. 82
Griffith & Wedge Co. 141
Homestead Valve Mfg. Co. 94
Hooven, Owens, Rentschler Co. 141
Lunkenheimer Co., The. 4
McClave-Brooks Co. 12
Neemes Bros. 104
Salamander Grate Bar Co. 104
Treadwell & Co., Inc., M. H. . 102

Castings, Steel

Hooven, Owens, Rentschler Co. 141

Cement, Heat Resisting

Harbison-Walker Refractories Co. 129

Cement, Iron

Johns-Manville Co., H. W. 107
Smooth-On Mfg. Co. 6

Cement, Pipe Joint

United States Graphite Co. . . 114

Cement, Rubber

Peerless Rubber Mfg. Co. 8

Chimneys, Brick

Kellogg Co., M. W. 109

Chimneys, Steel

Keeler Co., E. 126
Morrin Climax Boiler Co. 125

Clocks

American Steam Gauge and Valve Mfg. Co. 66, 67
Ashton Valve Co., The. 95
Schaeffer & Budenberg Mfg. Co. 110

Clutches, Friction

Allis-Chalmers Co. 144
Cresson Co., Geo. V. 88

Coal

Consolidation Coal Co. 13

Coal and Ash Handling Machinery

Green Engineering Co. 102
Jeffrey Mfg. Co. 101

Cocks, Blow-off

Elliott Co. 7
Hancock Inspirator Co. 90

Cocks, Gage

American Steam Gauge and Valve Mfg. Co. 66, 67
Chaplin-Fulton Mfg. Co. 127
Huyette Co., Inc., Paul B. 121
Jenkins Bros. 71
Lunkenheimer Co., The. 4
Ohio Blower Co. 138
Ohio Brass Co. 109
Penberthy Injector Co. 11
Reliance Gauge Column Co. . . 127
"S-C" Regulator Co. 127
Schaeffer & Budenberg Mfg. Co. 110
Wright Mfg. Co. 98

Cocks, Steam

Dart Mfg. Co., E. M. 97
Lunkenheimer Co. 4
National Tube Co. 75
Robertson & Sons, Jas. L. 79
Schutte & Koerting Co. 106

Combustion Chamber, Back Arch

Betson Plastic Fire Brick Co. . 75
Harbison-Walker Refractories Co. 129
McLeod & Henry Co. 128

Combustion Recorders

Precision Instrument Co. 126
Uehling Instrument Co. 126

Compound, Commutator

Dixon Crucible Co., Jos., 116

Condensers
Allis-Chalmers Co.....144
Anderson Co., V. D..... 98
Baragwanath & Son, Wm.... 86
Cameron Steam Pump Works, A. S.....120
Connersville Blower Co., The. 88
Deane Steam Pump Co.....121
De La Vergne Machine Co....138
Epping-Carpenter Co.....121
Griscom-Spencer Co. 84
Kellogg Co., M. W.....109
McGowan Co., John H.....120
Minneapolis Steel & Mchy. Co.137
Schutte & Koerting Co.....106
Wheeler Cond. & Engr. Co....121
Wheeler Mfg. Co., C. H.....122

Controllers, Feed Water
Chaplin-Fulton Mfg. Co.....127
Elliott Co. 7
Mason Regulator Co..... 91
Northern Equipment Co.....126
Squires Co., C. E.....101

Conveying Machinery
Jeffrey Mfg. Co.....101

Cooling Plants
Power Specialty Co.....108
Schutte & Koerting Co.....106

Cooling Towers
Baragwanath & Son, Wm.... 86
De La Vergne Machine Co....138
Wheeler Cond. & Engr. Co....121
Wheeler Mfg. Co., C. H.....122

Correspondence Schools
American School of Corres...101
Branch School of Engineering, Joseph G. 116
International Corr. Schools... 73

Couplings, Flexible Shaft
Bruce-Macbeth Engine Co.....134
Cresson Co., Geo. V..... 88
Hooven, Owens, Rentschler Co.141

Couplings, Pipe
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Coverings, Pipe and Boiler
Johns-Manville Co., H. W....107

Cranes
Yale & Towne Mfg. Co.....121

Crank Pin Oiler
Richardson-Phenix Co. 111

Curbs, Manhole
Armstrong Mfg. Co.....108

Cylinder Boring Bars
Rooksby & Co., E. J.....142
Underwood & Co., H. B.....144

Cylinders, Rebored
Rooksby & Co., E. J.....142
Underwood & Co., H. B.....144

Die Stocks
Armstrong Mfg. Co.....108
Bignall & Keeler Mfg. Co....116
Curtis & Curtis Co..... 81
Toledo Pipe Threading Mach. Co. 141

Draft, Mechanical
Buffalo Steam Pump Co.....122
Parson Mfg. Co.....104
Schutte & Koerting Co.....106
Sturtevant Co., B. F..... 84
Turbo-Blower Co.....110
Wing Mfg. Co., L. J..... 96

Drills, Upright
Barnes Co., W. F. & John....132

Drying Apparatus
De La Vergne Machine Co....138

Dust Collectors
Ohio Blower Co.....138
Schutte & Koerting Co.....106
Sturtevant Co., B. F..... 84

Dynamos
Allis-Chalmers Co.....144
American Engine Co.....141
Bruce-Macbeth Eng. Co.....134
Fort Wayne Electric Works...133
Ridgway Dynamo and Engine Co. 141
Sturtevant Co., B. F..... 84
Terry Steam Turbine Co.....132

Economizers, Fuel
Sturtevant Co., B. F..... 84
Westinghouse Machine Co....146

Ejectors
American Injector Co.....124
Beggs & Co., James.....131
Hayden & Derby Mfg. Co..... 90
Kuleaid Bros. 96
Lunkenheimer Co..... 4
Ohio Injector Co.....4th cover

Ejectors—*Continued.*
Penberthy Injector Co..... 11
Schaeffer & Budenberg Mfg. Co.110
Schutte & Koerting Co.....106

Electric Current
New York Edison Co.....134

Engine Repairs
Rooksby & Co., E. J.....142
Underwood & Co., H. B.....144

Engine Stops
Locke Regulator Co.....106
Schutte & Koerting Co.....106

Engineers, Consulting
Power & Mining Mchry. Co...139

Engines, Combustion
Allis-Chalmers Co.....144
Beggs & Co., James.....131
Bogart Gas Power Engineering Co. 139
Bruce-Macbeth Eng. Co.....134
Buckeye Engine Co.....142
De La Vergne Machine Co....138
International Harvester Co. of America 137
Minneapolis Steel & Mchy. Co.137
Otto Gas Engine Works.....139
Power & Mining Machry. Co..139
Struthers-Wells Co.....138
Turner-Fricke Mfg. Co.....139
Westinghouse Machine Co....146
Wisconsin Engine Co.....136

Engines, Oil
Remington Oil Engine Co....136

Engines, Pumping
Hooven, Owens, Rentschler Co.141
McGowan Co., John H.....120

Engines, Steam
Allis-Chalmers Co.....144
American Eng. Co.....141
Ames Iron Works.....144
Ball Engine Co.....145
Beggs & Co., James.....131
Buckeye Engine Co.....142
Buffalo Steam Pump Co.....122
Cooper Co., C. & G.....138
De La Vergne Machine Co....138
Fitchburg Steam Engine Co..141
Griffith & Wedge Co.....141
Griscom-Spencer Co. 84
Harris Steam Eng. Co., Wm. A.144
Harrisburg Fdry & Mach. Wks.141
Hewes & Phillips Iron Wks..140
Hooven, Owens, Rentschler Co.141
McIntosh, Seymour & Co....142
Minneapolis Steel & Mchy. Co.137
Perkins Co., Jno. B..... 97
Providence Engineering Wks.140
Ridgway Dynamo & Engine Co.141
Rollins Engine Co.....143
Skinner Engine Co.....141
Sturtevant Co., B. F..... 84
Vilter Mfg. Co.....140
Watts-Campbell Co.....142
Westinghouse Machine Co....146
Wisconsin Engine Co.....136

Exhaust Heads
Burt Mfg. Co..... 16
Elliott Co. 7
Hoppes Mfg. Co..... 82
Ohio Blower Co.....138
Patterson & Co., Frank L.... 83
Robertson & Sons, Jas. L.... 79
Sturtevant Co., B. F..... 84
Watson & McDaniel.....122
Whitlock Coil Pipe Co..... 86
Wright Mfg. Co..... 98

Expansion Joints
Greene, Tweed & Co., 112, 4th cover
National Tube Co..... 75

Fans, Electric
Fort Wayne Electric Wks....133
Sturtevant Co., B. F..... 84
Wing Mfg. Co., L. J..... 96

Fans, Exhaust and Ventilating
Anderson Co., V. D..... 98
Buffalo Steam Pump Co.....122
Power Specialty Co.....108
Schutte & Koerting Co.....106
Sturtevant Co., B. F..... 84
Turbo-Blower Co.....110
Wing Mfg. Co., L. J..... 96

Feed Water Weighers
Kennicott Co. 127

Feeders, Boiler Compound
Richardson-Phenix Co. 111

Feeders, Furnace
Ohio Blower Co.....138

Filters, Oil
Burt Mfg. Co..... 16
Elliott Co. 7
Franklin Oil Filter Co.....112
Liberty Mfg. Co..... 7
Nugent Co., Wm. W.....112

Filters, Oil—*Continued.*
Richardson-Phenix Co.....111
Robertson & Sons, Jas. L.... 79
Wright Mfg. Co..... 98

Filters, Water
Beggs & Co., James.....131
Griscom-Spencer Co. 84
Scaife & Sons Co., Wm. B....126

Fire Clay
Betson Plastic Fire Brick Co.. 75
Harbison-Walker Refractories Co. 129
McLeod & Henry Co..... 128

Firebox Blocks
Betson Plastic Fire Brick Co.. 75
Harbison-Walker Refractories Co. 129
McLeod & Henry Co.....128

Fittings, Ammonia
American Steam Gauge and Valve Mfg. Co.....66, 67
De La Vergne Machine Co....138
Greene, Tweed & Co., 112, 4th cover

Fittings, Pipe
Jefferson Union Co..... 89
Lunkenheimer Co. 4
National Tube Co..... 75
Pittsburg Valve Fdry. & Construction Co. 97
Trimont Mfg. Co.....118

Fittings, Steel
Nelson Valve Co..... 92

Flanges
Dart Mfg. Co., E. M..... 97
Jefferson Union Co..... 89
National Tube Co..... 75

Floats
Anderson Co., V. D..... 98
Reliance Gage Column Co....127

Flue Gas Analysis Instruments
Carb-Ox Company 126
Pierce Co., Wm. B.....2d cover
Precision Instrument Co.....126

Forgings, Drop
Williams & Co., J. H.....113

Furnace Door Arch
Harbison-Walker Refractories Co. 129
Holyoke Steam Boiler Works. 125
McLeod & Henry Co.....128

Furnace Linings
Harbison-Walker Refractories Co. 129
Holyoke Steam Boiler Works..125

Furnaces, Smokeless
Green Engineering Co.....102
Holyoke Steam Boiler Works. 125
McClave-Brooks Co..... 12
Mellor Furnace Engr. Co....127
Murphy Iron Works.....104

Gage Boards
American Steam Gauge and Valve Mfg. Co.....66, 67
Ashton Valve Co., The..... 95

Gage Glasses
American Steam Gauge and Valve Mfg. Co.....66, 67
Ashcroft Mfg. Co..... 90
Chesterton Co., A. W..... 72
Garlock Packing Co..... 9
Peerless Rubber Mfg. Co..... 8
Penberthy Injector Co..... 11
Rogers Co., H. A.....140
Schaeffer & Budenberg Mfg. Co.110
Von Kokeritz & Co., R. G.... 82

Gage Testing Outfit
American Steam Gauge and Valve Mfg. Co.....66, 67
Ashton Valve Co., The..... 95
Schaeffer & Budenberg Mfg. Co.110

Gages, Draft
American Steam Gauge and Valve Mfg. Co.....66, 67
Ashton Valve Co., The..... 95
Bristol Co.....4th cover
Precision Instrument Co.....126
Schaeffer & Budenberg Mfg. Co.110

Gages, Pressure
American Steam Gauge and Valve Mfg. Co.....66, 67
Ashton Valve Co., The..... 95
Crosby Steam Gage & Valve Co. 77
Keeler Co., E.....126
Schaeffer & Budenberg Mfg. Co.110

Gages, Recording
American Steam Gauge and Valve Mfg. Co.....66, 67
Ashton Valve Co., The..... 95
Bristol Co.....4th cover

Gages, Recording—*Cont.*
Ohio Injector Co.....4th cover
Precision Instrument Co.....126
Schaeffer & Budenberg Mfg. Co.110
Uehling Instrument Co.....126

Gages, Vacuum
American Steam Gauge and Valve Mfg. Co.....66, 67
Ashton Valve Co., The..... 95
Greene, Tweed & Co., 112, 4th cover
Schaeffer & Budenberg Mfg. Co.110
Schutte & Koerting Co.....106

Gages, Water
American Steam Gauge and Valve Mfg. Co.....66, 67
Greene, Tweed & Co., 112, 4th cover
Huyette Co., Inc., Paul B....121
Jenkins Bros..... 71
Lunkenheimer Co..... 4
Ohio Blower Co.....138
Ohio Brass Co.....109
Penberthy Injector Co..... 11
Reliance Gauge Column Co...127
Schaeffer & Budenberg Mfg. Co.110
Wright Mfg. Co..... 98

Gas Exhausters
Ohio Blower Co.....138
Parson Mfg. Co.....104

Gas Producers
Bogart Gas Power Engineering Co. 139
De La Vergne Machine Co....138
Gas Power Machinery Co....135
Griscom-Spencer Co. 84
Minneapolis Steel & Mchy. Co.137
Power & Mining Machry. Co..139
Wisconsin Engine Co.....136

Gaskets
Cancos Mfg. Co.....106
Chesterton Co., A. W..... 72
Diamond Rubber Co.....108
Eureka Packing Co.....79, 109
Garlock Packing Co..... 9
Greene, Tweed & Co., 112, 4th cover
Jenkins Bros..... 71
Johns-Manville Co., H. W....107
Keeler Co., E.....126
New York Belting & Packing Co., Ltd..... 10
Peerless Rubber Mfg. Co..... 8
Smooth-On Mfg. Co..... 6

Gears
Cresson Co., Geo. V..... 88
New Process Raw Hide Co... 88

Generating Sets
American Engine Co.....141
Fort Wayne Electric Wks....133
Harris Steam Engine Co., Wm. A. 144
Harrisburg Foundry and Machine Works.....141
Ridgway Dynamo & Engine Co.141
Sturtevant Co., B. F..... 84

Governors, Pump
Chaplin-Fulton Mfg. Co.....127
Elliott Co. 7
Foster Engineering Co..... 94
Hughson Steam Specialty Co.. 94
Locke Regulator Co.....106
Mason Regulator Co..... 91
Northern Equipment Co.....126
Schade Valve Mfg. Co..... 95
"S-C" Regulator Co.....127
Squires Co., C. E.....101
Watson & McDaniel Co.....122

Governors, Pump Speed
Mason Regulator Co..... 91

Graphite
Dixon Crucible Co., Jos.....116
Garlock Packing Co..... 9
Greene, Tweed & Co., 112, 4th cover
United States Graphite Co...114

Grates
Armstrong Mfg. Co.....104
Babcock & Wilcox Co.....125
Beggs & Co., James.....131
Casey-Hedges Co.....125
Green Engineering Co.....102
Long Grate Bar Co.....102
Martin Grate Co.....103
Mellor Furnace Engr. Co.....127
McClave-Brooks Co..... 12
Neemes Bros.....104
Perfection Grate Co.....104
Robertson & Sons, Jas. L.... 79
Salamander Grate Bar Co....104
Standard Grate Co.....104
Treadwell & Co., M. H.....102
Washburn & Granger Co..... 102

Grease
Albany Lubricating Co.....117
Dearborn Drug & Chemical Works 5
Dixon Crucible Co., Jos.....116
Keystone Lubricating Co..... 3
United States Graphite Co...114
Walton Co., F. S.....14, 15